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Edited by

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THE TEA RESEARCH INSTITUTE.

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EDITORIAL.

MOISTURE IN TEA.

Attention is drawn to the note in this issue by Dr. Evans dealing with tea samples sent to the Institute for report.

The warning issued by the Institute in regard to the necessity for more careful checking of drying conditions has evidently been widely acted upon, and in the last three or four months nearly eight hundred samples of tea have been sent for report as to moisture content and firing generally. In view of the amount of work, largely purely routine in nature, involved in these determinations, it is necessary to define the attitude of the Institute in this matter. The Institute is naturally prepared to give superintendents the fullest possible assistance in checking their firing methods and in working out proper conditions of drying. In order that such work may be of the widest possible application, however, superintendents are asked in return to co-operate by forwarding in every case with their samples the information detailed in Dr. Evans' note. If this be done valuable data in regard to different types of dryers will rapidly be accumulated which should be of general interest.

On the other hand, the Institute cannot undertake the regular routine examination of factory breaks for moisture content. Such an undertaking would take up far too much of the time of the Staff, to the serious detriment of more important work.

It is realised, however, that a knowledge of the moisture contents of teas prior to packing is of importance, as the necessity, or otherwise, of final firing can only be decided on such data. In order, therefore, that superintendents may be in a position to carry out such determinations themselves, the Institute has approached various instrument makers with suggestions for a type of apparatus suitable for factory conditions. Further particulars will be announced in due course.

FACTORY HANDBOOK.

It is regretted that the necessity for further revision has delayed the publication of the new edition of the "Handbook of Factory Information". It is hoped, however, that this will now be issued about the end of March. It is necessary to emphasize that this Handbook deals only with the details of manufacture as carried out at St. Coombs, and it is not for a moment suggested that such methods can be applied without modification in factories where conditions may be totally different. It is hoped, however, to issue shortly a further publication dealing with manufacturing problems in a more general way.

TEA MACHINERY.

Elsewhere in this issue a brief account will be found of the new McKercher C.T.C. Roller, considerable numbers of which machines are said to have been installed in North India. Details of the performances of these machines are not yet available and further comment must be deferred until such data have been received.

SMALL-HOLDINGS IN TEA.

The Institute has recently been considering the question of small holdings in tea, the number of which is probably much greater than is generally realised. Owing to the small size of the great majority of these holdings the conditions obtaining therein are generally bad. The leaf is very frequently sold to hawkers and in most cases undergoes considerable vicissitudes before being manufactured, and it is obvious that there is here a source from which considerable quantities of very poor tea must reach the market. It is evident, therefore, that it is very desirable, both in the interests of the small-holders themselves and of the market generally, that efforts should be made to improve the conditions now obtaining. The organisation of such work, however, presents considerable difficulties which will be realised from the figures given below which relate to holdings in the Gampola and Nawalapitiya areas alone.

Total number of holdings reported ...	1803
Holdings of less than 1 acre ...	499
Over 1 acre but less than 5 acres	1014
Over 5 acres but less than 10 acres	178
Over 10 acres but less than 20 acres	71
Over 20 acres but less than 50 acres	33
Over 50 acres	7

PRUNING EXPERIMENTS.

The pruning experiments to be carried out at Peradeniya and Galatura (vide *The Tea Quarterly*, 1930, **4,** 103) will be commenced at the end of April.

NETTLE GRUB.

Nettle Grub has now been gazetted a pest under the Plant Pest Ordinance No. 10 of 1924. The notification relates to the Uva Province only, in which it is now incumbent on superintendents to report to the Department of Agriculture the presence of the pest when found and to collect the cocoons.

EXPORTS OF DUTCH TEAS.

In view of the possibility of a preferential tariff on tea being introduced in the next English Budget and the likelihood of intensified

competition by Dutch teas in some of the smaller markets, the following figures relating to the export of Java teas during 1931 are of interest:

Country	Imports of Java teas in kilos (2·2 lb.)		Percentage increase in 1931 over 1930
	1931	1930	
Australia ...	11,078,638	10,394,636	6
Egyptian Ports ...	2,687,350	1,296,610	107
Mesopotamia ...	3,432,440	2,483,964	38
British South Africa ...	549,338	346,483	58
South America ...	1,088,491	749,409	45

Exports of Java teas to these centres therefore rose in 1931 by three and a half million kilos or rather more than seven and three-quarter million pounds.

During the same period Ceylon tea exports increased by 24% only in the case of Egypt and diminished by 8% in Irak and by nearly 50% in Australia. Indian teas gave diminished figures for all the above centres. Ceylon interests in these areas obviously require close attention.

ROLAND V. NORRIS.

THE "NETTLE GRUB" PEST OF TEA IN CEYLON.

G. D. AUSTIN.

(Continued).

NATADA NARARIA, Mo.

This Nettle Grub has been a great plague on one or two estates in Uva. Although the smallest of the stinging pests, it has in the past defoliated large patches of tea. The fact that they feed on the underside of the leaves and do not bite through them until they have grown considerably renders the detection of an attack much later than is desirable. It may be pointed out, however, that at the conclusion of an attack, the next one may be expected to begin about a fortnight later. Whether it does so or not will depend to a great extent on weather conditions, a storm occurring at this period being most likely to bring about an emergence of moths.

FOOD PLANTS.

Food plants of insects may be said to be divided into two classes, viz., "favourite hosts" and "casual hosts", while the former may yet be sub-divided into "alternate hosts" and "additional hosts". "Favourite hosts" or "preferred hosts" are those plants which are most favoured or preferred by insects, and on which the insect is capable of breeding.

"Casual hosts" are the plants on which a gravid female may oviposit, irrespective of the fact that the plant might or might not be a suitable food plant for its offspring.

"Alternate hosts" are those plants on which an insect is capable of breeding when it is unable, for some reason or the other, to propagate on its "favourite host".

"Additional hosts" may be said to be those plants (perhaps of secondary importance) on which a pest is observed to breed while it is simultaneously on its "preferred" or "favourite host".

Tea undoubtedly is the favourite host of *Natada nararia*, while Dadap (*Erythrina lithosperma*) is its "additional" host. The following is a list of "casual hosts" recorded from Passara—*Gliricidia maculata*; *Crotalaria* spp; *Tephrosia candida*; "Gums" (*Eucalyptus* spp.); Toona (*Cedrela toona*); *Ficus religiosa*; *Citrus* spp; Patna Oak (*Careya arborea*); Roses; Honeysuckle; and Cannas.

It is conjectured that perhaps coffee may have been *Natada's* original host in Ceylon, since this crop is one of the host plants recorded in India. There is however, no conclusive evidence available in support of this conjecture, while it sounds very improbable

because, if *Natada* had been present on coffee, it is very unlikely that it would have escaped the notice of either Neitner or Green and especially the latter, who was such a keen observer.

It is commonly believed in Uva, that Nettle Grubs breed in the patna, and that patnas are sources of infection. In other words wild plants growing on patnas are the alternate host of *Natada* when the pest is not in the tea. A careful search was made through the patnas round Passara, when there was no *Natada* on the tea, in order to find what *alternate* host plants might be harbouring the pest. On no occasion were any grubs found nor was there any evidence to show that the pest had even existed in those areas. Proof that Nettle Grubs had fed, or attempted to feed, was observed on a few wild plants on the patnas bordering the tea, but never at a considerable distance away from the latter. Damage observed in such cases showed symptoms of attack by only the *young* stages of the grubs. It seems reasonable to think that moths invaded the patna from the tea. Moths, as will be explained later, deposit their eggs promiscuously on many kinds of plants, and especially those with a smooth surface, and those which would give a certain amount of protection to a gravid female.

Consequently, during a severe outbreak in Passara in 1928, as recorded by Hutson, [19] "young *Natada* larvae" were found "feeding on eighteen different wild plants growing in a ravine bordering one side of the field and on the adjoining patna across the ravine". These wild plants were evidently casual hosts only during that particular outbreak, and were noticed on the patna and on the tea at the same time. Observations are still being made to ascertain whether *Natada* grubs are able to complete their life cycle on these wild plants.

EGGS.

Eggs are pale-yellow, flat, oval-shaped, scale-like objects, deposited singly on the upper surfaces of mature leaves. Very rarely, and perhaps only during severe outbreaks, have eggs been found on tender leaves. A day previous to hatching the eggs turn brown, and with the aid of a pocket lens it is possible to see the young larvae through the almost transparent shells or egg coverings.

OVIPOSITION

Eggs are deposited promiscuously on the upper surfaces of leaves, especially those with a smooth surface, and on which a gravid female may happen to rest.

Oviposition takes place at night and commences on the day following the emergence of the female moth from its cocoon. Moths become active at dusk and egg laying begins by 6 or 6-30 p.m. and

continues till midnight. In several cases it was observed that the majority of eggs laid in a single night were deposited before 8 p.m. while, on the aggregate, the majority of eggs were deposited during the first three or four days after oviposition commenced. The maximum number of eggs deposited on a single leaf in the field, and counted after the examination of several hundred leaves, was 45.

OVIPOSITION EXPERIMENTS.

The following procedure was adopted when over a hundred female moths were isolated on different occasions to ascertain particulars regarding oviposition. Cocoons were collected in the field and on moths emerging they were paired and placed in various types of cages, e.g., huricane lantern chimneys, glass tumblers, and glass tubes of various sizes. In some instances two males were placed in each cage to ensure fertilization. The moths were fed on a solution of sugar and water. Owing to the limited number of cages available it was not possible to transfer the females daily into fresh cages and thereby make correct counts of the eggs deposited every night. The alternative was to keep the moths in the same cages till they died and make an estimate of the eggs which hatched daily and those which failed to hatch at all.

INCUBATION.

Under insectary conditions eggs commenced to hatch from 5 to 8 days after oviposition, with an average of 6 days. (Results of 95 experiments).

LARVAE OR GRUBS.

The following description is taken from Hutson [17]:—

"*Caterpillars.*—These are about 1/25th inch long on hatching and of a dull whitish colour, but become pale-green after feeding has begun. The body is fringed with minute tufts of white stinging hairs and there is a double row of still smaller spiniferous tubercles along the back. The young Nettle Grubs move to the underside of the leaves soon after hatching and begin eating away small portions of the under-surface, leaving only a thin skin, the upper epidermis. When a number of young caterpillars are feeding on the same leaf, this soon becomes marked with numerous small brownish spots. After about two weeks of feeding the caterpillars are able to eat right through the leaves, which very soon assume a notched and ragged appearance. By the time grubs are full grown the damage is more marked and if the outbreak happens to be severe, complete defoliation is not an uncommon sight—the bare stems standing erect and the bush looking more like a broom or bundle of twigs."

When several hundred larvae were bred in the insectary, in varous types of cages, the larval period ranged from 29 to 42 days with an average of 36 days.

COCOONS.

Cocoons are dark-brown, or purplish-brown, globular objects about 1/6th inch in diameter, covered with a thin webbing of brown hairs. They are usually found beneath the bush, round the collar, under stones, among dead leaves, in crevices, and during severe infestations on the lower branches of the tea bush.

The pupal period, or stage of the grub within the cocoon during its transformation, prior to emerging as a moth, occupies 18 to 22 days with an average of 21 days.

MOTHS.

The description is taken from Rutherford [13].

"*Male*.—Forewing whitish at base, reddish-brown, with a central black dot in middle area. The reddish-brown area is bounded outwardly by a black line backed by a much more distinct whitish band. The fringe and edge of the wing is broken. Antennae are bipectinate. Expanse 12-20 mm.

"*Female*.—The female is larger (22 mm.) and the antennae are simple. Forewing reddish-brown, except for a broad band of paler-brown towards the apex. At the junction of these two areas is a black band. Black scales are scattered all over the wing."

Moths are nocturnal in their habits and remain in hiding during the day.

As regards the proportion of sexes emerging from cocoons collected in the field, many observations showed that males emerged earlier than females, and that as the period of emergence proceeded the females predominated. In the aggregate, however, there was a slight preponderance of males over females. Of a total of 3289 moths observed on emergence, 1733 were males, and 1556 were females, or nearly 53% males and 47% females.

Mating first takes place on the night of emergence and may last a couple of hours. It has also been observed to occur during the day. While in copula the heads of the moths are in opposite directions.

MOTHS.

Longevity.—It was noted that females and males lived an average of six days, while the maximum and minimum length of life for both sexes was 12 and 3 days respectively. This was ascertained when 224 moths, of which 101 were females and 123 males, were isolated in cages at different times of the year.

PARASA LEPIDA. Cram

Parasa lepida—the blue striped Nettle Grub, originally a pest of coffee, and then of tea, is perhaps not such a pest of even the latter as it is of coconuts. In 1929 [23] it was reported "to have almost defoliated six acres (of coconuts) on two estates off Chilaw." It is the only local species of Nettle Grub known to attack a variety of plants of economic importance. In addition to the three hosts mentioned, it has been known to breed on cacao, plantains or bananas, and on roses. Even in India its list of food plants is quite varied and consists of mango, castor, *Ficus* spp. and the country almond (*Terminalia catappa*).

A characteristic of the pest is that the grubs are gregarious and hence damage is limited to definite areas. In the few instances it has been recorded as causing "extensive damage", it is doubtful as to whether *Parasa* alone was responsible for such defoliation, or whether it was the combined attack of *Parasa* along with the other species of Nettle Grubs, like *Thosea* and *Natada*, with which it is associated when on tea.

Its distribution is wide; it has been reported from almost sea level to elevations approximating 5,000 ft. Previous to 1914 it was "reported from Ratnapura, Peradeniya, Wattegama and Marawila" [18], and since 1928 it has been found in Badulla, Passara, Madulsima, and Pussellawa (on tea), Chilaw and Kurunegalle (on coconuts).

LIFE-HISTORY.

In Passara its life-history has not been worked out in detail as yet. Moths in captivity lived a maximum of 9 days, and pupal periods ranged from 45 to 60 days. Larval periods must be extremely long because when large-sized grubs were once received for identification they lived for 7 weeks before commencing to construct their cocoons.

Descriptions of the stages are taken from Rutherford [13] and Hampson [4].

"Eggs are oval, flat and overlap each other.

"The caterpillar is about $\frac{3}{4}$ inch* long when full grown. The general colour is greenish-yellow with three broad, pale-blue longitudinal stripes each edged with blue-black, one mid-dorsal and the others lateral. Between the mid-dorsal and lateral stripes on each side is a row of tubercles bearing spines in tufts. Another row runs ventral of each lateral stripe. The spines are green with black tips.

* This is an understatement, the average maximum length being about $1\frac{1}{4}$ in.

Several of the spines on two pairs of dorsal thoracic tufts and also on a pair of tufts near the anal end are modified into stout, brownish, cylindrical processes. Arranged round the posterior end are four large tufts of short black hairs. On the dorsum of the prothorax are two small, black plates of chitin, straight on their mesal margins." —Rutherford.

MOTHS.

"*Male*.—Head green, red-brown at the sides; thorax green with a brown stripe on the vertex; abdomen brown; forewing pea-green; a red-brown basal patch on the costa (front edge of the wing), outer area red-brown, widest at inner margin. Hindwing yellowish at base, red-brown towards outer margin. Legs with joints pale-tipped. Expanse 30 mm.

"*Female*.—The red-brown stripe on the thorax wider and nearly the whole of the hindwing red-brown. Expanse 42—50 mm."

THOSEA CERVINA Mo.

Within recent years *Thosea cervina* Mo. has rather quickly assumed a status of economic importance as a pest of tea, almost equal to that held by *Natada nararia*, the 'Fringed Nettle Grub', during the last three decades or more. In Passara, since 1928, it has superseded *Natada* in a few localities.

In India [7] it first attracted attention in 1894 when it was reported as a pest of tea in Assam—hence its common name "the Assam Nettle Grub". In Ceylon it was not recognised as a pest till 1906 when it appeared in millions on tea in Bandarawela. No other reference is available of its presence in any part of the Island till 1914 when Rutherford [13] recorded it on the Pepper Vine (*Piper nigrum*), also from Bandarawela. In 1921 it appeared simultaneously in Dolosbage and Wattegama during the month of August, and the following year in the Badulla district. Since 1928 it has been reported from several localities in the Uva and Central Provinces.

LIFE-HISTORY AND HABITS.

In the insectary it has been one of the most difficult insects to breed. Moths have either failed to emerge from cocoons spun in the cages, or, when they have emerged, failed to make and oviposit fertile eggs. Over fifty female moths were isolated during the period under review.

On one occasion a few eggs (six) were casually observed on a leaf picked in the field. They were elliptical in shape, yellow in colour, flat, rather shiny, and situated along the margin, on the under

surface of the leaf. The eggs hatched in a couple of days and the larvae or grubs lived 45 to 66 days before reaching pupation, and the adults took 35 to 47 days to emerge from their cocoons. Female moths lived a maximum of 12 days and males a maximum of 11 days.

Moths emerge from their cocoons at dusk and are very active during the earlier part of the night, and more especially the male. The female moth is larger than the male: the former is of a light brown colour, while the latter is of a very much darker shade. In the insectary eggs were laid singly or in masses on both sides of the foliage offered. The larvae emerging are of a pale-yellow colour and gradually assume their pretty colouration as they grow older. The writer is obliged to Dr. Hutson of Peradeniya for the following descriptions:

"*Young larvae*.—Yellowish-green with 5 sub-dorsal pairs of orange-coloured spiniferous tubercles, spines sometimes dark coloured. A sub-lateral series of green tubercles with pale spines. Dorsal band divided into anterior, middle and posterior areas, all purplish and separated by two greenish areas. A medium dorsal whitish line running nearly the length of the body.

"*Full grown larva*.—Nearly $1\frac{1}{4}$ inches long, greenish to yellowish-green, sometimes turning yellowish above and pinkish below before pupation. Dorsal band very variable in shape, colouration and markings. Some with narrow white dorsal bands, others with broader bands of colours varying from lilac, through purplish-brown to brownish. Spines on sub-dorsal series of tubercles tipped with black, those on sub-lateral series paler.

"Cocoon, broadly oval to globular, smooth, dark-brown, rather like a small tea seed."

THOSEA RECTA Hmp.

Thosea recta was the first Nettle Grub to cause a scare in the Island. Originally described by Hampson [4] in 1892, it appeared in the form of a pest of tea in 1899 when it broke out in the Morawak Korale. Since then it has been reported from at least fourteen planting districts, and is the Nettle Grub with the second widest distribution. In Uva it appears along with *Thosea cervina* but never in large numbers. It is presumed that it is probably a species more adapted to the mid-country.

Its life-history has been exceedingly difficult to work out under insectary conditions. It is evidently more susceptible to wilt than *Thosea cervina*, because grubs kept under observation frequently succumbed to this disease.

On the few occasions this insect succeeded in completing a life cycle, the following facts were ascertained. Larval period 49 to 56 days; pupal stage 30 to 33 days; longevity of female moths 9 days, and of a male moths 6 days.

The following description is taken from Rutherford. [13]

"The caterpillar is about $\frac{1}{2}$ in long. Small thoracic legs are present.

"The colour is variable. The ground colour is bright orange or green and there are three, bright crimson, purplish or brownish areas on the dorsum, the most anterior of which is narrow and slightly constricted at two points, the middle one broad and diamond shaped with a lateral expansion on each side, and the posterior one of intermediate width and more or less deeply constricted.

"The dorsal areas sometimes bear shining white spots, one at the caudle end of the most anterior, one near the cephalic end and one on each lateral expansion of the middle, and two, one behind the other, on the posterior dorsal area. There are two rows of spiny tubercles on each side, one just outside the dorsal areas and the two lower down on the side.

"The cocoon is attached to leaves or twigs. It is about 3/10th. of an inch long, oval, dark-brown with lighter patches. The adult escapes by a circular lid at one end. The pupal skin protrudes and may even come to lie outside the ruptured cocoon."

Food plants:—Tea and *Albizzia* spp.

THOSEA CANA Wlk.

The writer is not familiar with this particular species of Nettle Grub. It is quite likely that, if it were seen, it was mistaken for *Thosea recta*, a species it is reputed to have a striking resemblance to. Both Green [5] and Rutherford [13] have recorded their inability to distinguish the larvae. The former wrote: "The caterpillar of this moth (i.e., *Thosea cana*) is practically indistinguishable either in form or colour from that of *Thosea recta*. It is perhaps more usually without the red patches on the back, but this character is very variable in both species. The two insects have similar habits and appear to be equally destructive. The moth of *T. cana* may be distinguished by its more uniform greyish-brown colour and by the absence of the short white streak which marks the forewing of *T. recta*. *T. cana* has two indistinct brownish lines across the wing, with a small brown speck in the space between them."

The food plants on which it has been observed are tea and *Albizzia*.

A feature of its distribution is that it has never been recorded from Uva. Rutherford [13] records "Kelani Valley, Elpitiya, Avisawella, Galaha and Deniyaya." Ratnapura and Balangoda are additional localities from Peradeniya records.

SCOPELODES VENOSA

Green [8] was the first to discover *Scopelodes venosa* on tea when he recorded it from Peradeniya in June 1903. It is obviously a very rare species because it was not observed or recorded again till December 1930 when the writer received a solitary specimen from an estate in Passara. In February this year, two young larvae were found among a collection of *Thosea* grubs sent in from another estate in Passara. In June a solitary grub was received from Demodera. Attempts to breed the previous few larvae were not successful as the grubs died within a couple of days. This may have been due to the rough handling the grubs must have received at the hands of the collecting podians.

The grub which came from Demodera was $1\frac{1}{2}$ inches long and rather broad. It was of a bright green colour, with two rows of large densely spined tubercles, and a conspicuous white, orange and dark blue band across the hinder part of its back.

After living for over a month in the insectary it spun a cocoon on a leaf. The cocoon is oval in shape, of a dark chocolate colour, $\frac{3}{4}$ inch in length and $\frac{1}{2}$ inch in diameter.

Food plants:—In addition to tea, according to Thwaites and recorded by Moore, [2] the grubs are nearly omnivorous on coffee, and roses.

SPATULICRASPEDA CASTANEICEPS Hmp.

This particular Nettle Grub appears to be indigenous to the Island, and Hampson [4] who originally described the insect, records it only from Ceylon. The writer is not aware whether it has been found elsewhere in the tropics.

As a pest of tea it first attracted attention in 1900 when it was reported from "several parts of the Kelani Valley", and Green [6] recorded it in his report for the year when he wrote the following descriptive note:

Spatulicraspeda——then known as *Spatulifimbria castaneiceps*, "has only recently attracted attention as a tea pest. It is a small and inconspicuous grub, of a chocolate brown colour, with a reddish saddle-shaped mark on the middle of the back and a few yellow spots. Though belonging to the family of "Nettle Grubs" this particular species is unprovided with the usual urticating spines. The cocoon is very small, broadly oval, smooth and compact. The male moth

is uniform dark purplish brown, with indistinct darker transverse bars across the forewings, the expanded wings measuring just half an inch. The female moth is rather larger, measuring three quarters of an inch across the wings, and is of a much paler shade of brown."

In February 1903 it was reported from Neboda. No reference is made to the grub during the following 11 years in any of the Entomological reports till Rutherford, [13] in 1914, referred to "two larvae of a different species" which he found among a colony of *Natada nararia*. He appears to have been unable to place them at the time as the "larvae perished" while under observation. But his description of the specimens is so accurate that it is beyond doubt that the "two larvae of a different species" were *Spatulicraspeda castaneiceps*.

In 1919 and 1921 Hutson recorded it 'from Up-Country' and in 1926 Light [18] reported an attack from Passara. During the last few years specimens have been received from Badulla, Madulsima, Lunugala, Demodera and Bandarawela. In every case the host was tea. It has not been found on any other host plant as yet.

LIFE-HISTORY AND HABITS.

Moths—emerge from their cocoons at dusk and mating occurs a couple of hours later. Oviposition takes place the following night and the period of oviposition lasts from 3 to 4 days. In the insectary moths of both sexes lived to a maximum of 11 days with an average of 6 days.

Eggs—are deposited singly on the upper surfaces of leaves and resemble those of *Natada* in their similarity to flat scales. They are most inconspicuous. The incubation period is nearly 7 days on the average.

Larvae—on hatching are almost microscopic and appear as greyish specks against the green background of the leaf on which they emerge. Grubs are found on both sides of the leaf. The larval period extends from 39 to 61 days with an average of 44 days.

Cocoons—are spun on the leaves and are conspicuous, greyish, oval-shaped objects. The pupal period, or stage with the cocoon, lasts from 15 to 33 days with an average of 16 days.

Distribution.—Though originally recorded from the Kelani Valley (1900), Neboda (1903) and Elpitiya (1926), it has during recent years only been recorded from Uva.

NAROSA CONSPERSA Wlk.

According to Hutson [19] this is one of the "gelatine grubs" which usually feed on the leaves of coconuts and ornamental palms." The writer has seen it listed among the Limacodids recorded in

Tennent's Natural History of Ceylon published in 1861. This list was compiled by Walker who originally described the insect somewhere between 1858 and 1861. Its first appearance as a pest of tea occurred in December, 1905 when it was recorded by Green [9] who commented as follows: "A small outbreak of a caterpillar pest (*Narosa conspersa* Wlk), on tea has been reported from the Uda-Pussellawa district. Though belonging to the family *Limacodidae* (which includes the notorious 'Nettle Grub') this particular insect has not previously attracted attention as a pest. It does not figure in Watt and Mann's Pests and Blights of the Tea Plant." Its next recorded appearance on tea was 1928 when Hutson [19] found it in the Badulla district along with other species of Nettle Grubs. Since then specimens have been received from Passara, Madulsima, Lunugala, Haputale, Demodera, Bandarawela and Talawakelle.

(Hampson [4] records its foreign distribution as "Nagas; S. Ceylon; Borneo.")

Food Plants.—Besides tea, coconuts and ornamental palms, it has been known to feed on cannas and breed on roses.

Description.—The following description is taken from Hampson [4]:

"*Moth.*—Head and thorax white, slightly spotted with red-brown marks. Forewing yellowish-white, spotted and streaked with red-brown marks, forming indistinct broken transverse oblique lines; a large ferruginuous patch near base of inner margin; two brown specks on outer margin. Abdomen and hindwing pale-yellow.

"*Larvae.*—Naked, oval, and transversely corrugated; with paired dorsal humps; green, with white sub-dorsal lines and a series of white sub-lateral spots; legs yellow and retractile.

"*Cocoons.*—Oval; whitish, with a circular brown spot at one end.

LIFE-HISTORY AND HABITS.

The life-history of *Narosa* was worked out on a few occasions. Cocoons collected in the field were placed in large muslin cages till adults emerged and mated. Otherwise it was difficult to detect the sexes. Mating lasts a few hours, and was observed to take place in the night and during the day as well. Pairs were also recorded to mate more than once. Moths lived a maximum of 12 days while in captivity. Eggs were invariably deposited on the sides of the cages, and on both sides of a leaf when a female did oviposit on the foliage offered. The maximum number of eggs deposited by a female was 235, and the incubation period was about 6 days on the average.

Larvae are exceedingly difficult to detect owing to the perfect harmonizing of their colour with the foliage on which they hide and feed. Cocoons are spun on the leaves and are very conspicuous owing to their whitish colour. They are sometimes mistaken for the cocoons of *Spatulicraspeda* and vice versa. But the cocoons of *Spatulicraspeda* are much smaller than those of *Narosa* and the latter possess the characteristic 'circular brown spot at one end.' The larval period of grubs bred in the insectary ranged from 33 to 41 days, and the pupal periods from 19 to 26 days with an average of 23 days.

BELIPPA LALEANA Mo.

The first authentic record of this gelatine grub as a pest of tea in Ceylon is Speyer's reference to it in the report of the Entomologist for 1917. Beyond listing it as one of the tea pests of the year he gives no further information regarding locality, etc. Six years later Dr. Hutson [17] included it in his list of the Nettle Grubs attacking tea. The same year (1923 it was recorded as the only caterpillar feeding on *Gliricidia maculata**. Subsequent to this the writer is not aware of any published record relating to the economic importance of this grub in the Island.

In July, 1931, one solitary larva of *Belippa laleana* was observed among a miscellaneous collection of caterpillars received from Madulsima and reported as damaging tea. In September the same year it was reported on an estate in the Badulla district, and the following month it was again received from Madulsima. By November it was observed on another estate in the Badulla district.

This seems to indicate that though this species might be considered of minor importance at the present moment, it is rather widely distributed in Uva.

Appearance of larva.—The larva or grub is rather squat, rounded, bluish-green, gelatinous, and slug-like in appearance and movement. Of the few specimens received during the year, the largest measured a little over 1 cm. in length.

Cocoon.—In the insectary two grubs pupated on the sides of the wooden cage. Prior to making their cocoons they spun a whitish silk-like substance which gave the grubs a certain amount of protection while they passed their stage of transformation from grub to pupa. The cocoons are light brown in colour and rather oblong.

Life-History.—Nothing is known of its life-history. The pupal period must be a long one because no moths have emerged as yet from cocoons formed sixteen weeks ago at the time of writing.

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THE NODULES OF LEGUMINOUS PLANTS.

C. H. GADD, D. Sc.

For many centuries practical agriculturists have realised that legumes, such as peas, beans and vetches, when grown under suitable conditions, enrich the soil for the succeeding crop; but it is only within modern times that a satisfactory explanation of that increased soil fertility was forthcoming.

The experiments of Lawes, Gilbert and Pugh in 1857 had led to the irresistible conclusion that plants in general obtained their nitrogen requirements from the soil and not from the atmosphere. This conclusion agreed with the results of field experiments except where leguminous plants were concerned. The very troublesome fact remained that leguminous crops require no nitrogenous manure, yet they contain large quantities of nitrogen, and the soil in which they are grown is enriched. The problem of where this nitrogen comes from remained unsolved for many years.

Hellriegel and Wilfarth in 1888 were able to show from experiments in sand culture that the growth of a non-leguminous plant, such as the oat, was directly proportional to the amount of nitrate supplied, and that at the end of the experiment the amount of nitrogen contained in the oat crop and sand was less than that originally supplied. The growth of a leguminous plant, such as the pea, under similar conditions was erratic. In some cases the peas behaved exactly as the oat, but in others the peas grew well even in sand containing no nitrogen, and in these cases there was always an increase of nitrogen at the end of the experiment. They concluded that some factor, which came into the experiment by chance, enabled the peas to obtain their nitrogen from the air.

Berthelot in 1885 had shown that certain micro-organisms in the soil were capable of assimilating gaseous nitrogen from the air; Lachmann in 1858, and Woronin in 1866, had shown that the nodules of leguminous plants contained bacteria. By connecting these two facts, Hellriegel and Wilfarth came to the conclusion that the bacteria in the nodules obtained gaseous nitrogen from the air and then handed on some of the resulting nitrogenous compounds to the plant. In other words the nodule bacteria constituted the factor which entered the experiments by chance and caused the conflicting results.

That this hypothesis was well founded was amply demonstrated. They found that legumes grew quite normally in soils lacking nitrogen, provided that these soils had not been previously sterilised. In sterilised soils pea plants behaved like oats, and obtained their nitrogen from the soil. But if to the sterilised soil was added an extract

of arable soil on which peas had previously been grown, the peas grew well even when the soil contained no nitrogen, and the resulting crop was rich in nitrogen. If, however, the extract was previously boiled, its addition produced no effect. They also showed that an extract which worked well for peas might be without effect on lupins. Further reference will be made to this finding.

The legumes which happened to grow satisfactorily in unsterilised soil and those from sterilised soil watered with soil extract had on their roots small tubercles or nodules, whereas in sterilised soil no nodules were formed. The presence of such tubercles had long been known on the roots of leguminous plants and various explanations had been offered of them. Frank in 1879 had shown that the formation of nodules could be prevented by sterilisation of the soil in which legumes were grown, and Marshall Ward not only proved that nodule formation is due to outside infection but that such infection could be brought about by placing pieces of old nodules in contact with the roots of growing legumes. It remained however for Beijerinck in 1888 to isolate the specific organism which produces the nodules, and to this he gave the name *Bacterium radicicola*.

Later researches have confirmed all of Hellriegel and Wilfarth's results. Laboratory experiments have shown conclusively that where sufficient precautions are taken to sterilise the soil and to prevent chance infection of the plant by *B. radicicola* no nodules result on the roots of legumes grown in it, and that, in the absence of root nodules, leguminous plants are dependent, like non-leguminous plants, on the nitrogen compounds in the soil for their supply of nitrogen. It is the bacterium within the nodule which has the power of assimilating gaseous nitrogen, and not the leguminous plant independent of the bacterium.

The question naturally arises whether the nodule bacterium fixes nitrogen in the absence of the leguminous host plant. To this question contradictory answers have been given and the problem cannot be regarded as completely settled. Various explanations have been offered for the differences in the results obtained. The purity of cultures employed has in some cases been doubtful, and other results are vitiated by faulty methods of analysis. Recent investigations point strongly to the fact that legume nodule bacteria do not fix atmospheric nitrogen when grown under ordinary laboratory conditions independent of the host plant. It would be foolish to say that these bacteria never fix nitrogen under any conditions because obviously no one can test all possible variations. There, however,

appears little justification for the assumption that the nodule bacteria can fix even small quantities of nitrogen when grown independently of the host.

Thus a leguminous plant and its nodule-forming organism are individually unable to assimilate gaseous nitrogen; when living together nitrogen fixation undoubtedly takes place in sufficient quantities to be of practical importance in increasing the nitrogen supply of cultivated soils and in reclaiming barren sand and clay soils.

Reference has already been made to Hellriegel and Wilfarth's experiments which indicated that the bacteria having a beneficial effect on peas might have no effect on lupins or serradella. This observation indicated that there was not one kind of nodule bacteria but two or more. Carefully designed cross inoculation experiments carried out by a number of workers have led to the conclusion that if classified with regard to the leguminous plants on which they are found, the nodule-forming organisms can be divided into the following 12 groups:—

(1) Clover group. Includes only species of the genus Trifolium.

(2) Alfalfa or lucerne group. Includes members of the genera Medicago, Melilotus and Trigonella.

(3) Cowpea group. A large one including several genera amongst which are, Vigna, Dolichos, Desmodium, Acacia, Arachis, Pueraria and Cassia.

(4) Vetch group. Includes species of Vicia, Lens, Pisum and Lathyrus.

(5) Soybean group, (*Glycine hispidus*).

(6) Bean group. Contains members of the genus Phaseolus but not *Phaseolus lunatus* (lima bean).

(7) Lupin group. Includes Seradella (*Ornithopus sativus*) in addition to the lupins.

(8) Hog peanut group, (*Amphicarpa monoica*).

(9) Lead plant group, (*Amorpha canescens*).

(10) Trailing wild bean group, (*Strophostyles helvola*).

(11) Common Locust, (*Robinia pseudo-acacia*).

(12) Wood's Clover, (*Dalea alopecuroides*).

The organisms belonging to any one group are incapable, as a rule, of producing nodules on the roots of plants belonging to any other group though they will form nodules on the roots of other members of the same group. Thus the nodule-forming organism which

is found on the roots of red clover (*Trifolium pratense*) will cause nodules on the roots of other plants belonging to the genus Trifolium. It is specific to that genus. On the other hand the organism which invades the roots of the cowpea (*Vigna sinensis*) will also invade plants belonging to other, and apparently not closely related, genera such as Acacia, Desmodium and Cassia, but will not induce nodules on clover or other plants not belonging to Group III above.

These facts are of practical importance because they indicate that the optimum benefit cannot be derived from leguminous plants unless the necessary specific organism is present in sufficient numbers to form the nodules, even when other conditions are favourable for satisfactory growth. The benefit derived from introducing soil from land on which a particular leguminous plant has been grown, to new land where the crop is being grown for the first time was probably realised before the reason for the practice was understood. Soil on which a particular legume, or another from the same group, has been successfully grown will contain the proper organisms for that legume; the legume becomes naturally inoculated. But where a legume from another group is being introduced the requisite organism may have to be provided artificially. For instance, red clover has been grown so long in parts of the United States that its nodule bacteria are present everywhere, but when soy bean was introduced, the crop had everywhere to be artificially inoculated, as the soy bean organism appears not to have been originally present in the United States. Similarly where lucerne has been grown in England, the best results have been obtained where the crop has been artificially inoculated with the proper organism.

Although it had long been recognised that all legumes are not inoculated by the same organism, very little difference in physiological and cultural characteristics was noticed between the cultures from different plants. After more careful study it became apparent that all strains were not exactly alike. Differences in size, morphology, flagellation and other characters were observed, and experienced workers have been able to place the various strains in groups corresponding with the cross-inoculation groups already referred to. It was also assumed that all cultures inoculating any one legume were alike, but later work drew attention to the fact that there were differences between the cultures of any one cross inoculation group. It was shown that differences in nitrogen fixing power were correlated with such differences in cultural characteristics. Different strains from soy bean and from lucerne on trial have been shown to be not equally efficient in fixing atmospheric nitrogen. It follows, therefore, that where artificial inoculation is practised, a strain of organism having a high nitrogen fixing ability is necessary.

The maintenance and restoration of humus and nitrogen in Ceylon tea soils is a matter of great economic importance. These soils owing to climatic conditions are subjected to a rapid destruction of humus, consequently the necessity for incorporating organic residues into the soil is deservedly receiving increasing attention. Economic conditions render it necessary that the organic matter must take the form of vegetable residues, i.e., green manures, and not of animal manures which have always held first place in European agriculture. Because legumes, when grown under favourable conditions, enrich the soil as a result of the fixation of atmospheric nitrogen, they have consequently been the first choice for green manures. It is here emphasised that the fixation of atmospheric nitrogen is carried on by the bacteria within the root nodules. In the absence of such nodules the nitrogen requirements of the legume are obtained directly from the soil; in such cases the legume is no more efficient in soil improvement than are many non-leguminous plants. Very little is known of the nodule-forming organisms present in Ceylon soils and in the nodules of indigenous leguminous weeds and crop plants. Many of the green manure plants grown on tea plantations are imported species, but in no case has the requisite nodule-forming bacteria been specially imported with the seed. Those species which have succeeded have no doubt found the requisite organism in the Ceylon soil, and it seems possible that the failure of other species to flourish has possibly resulted from the absence of the necessary organism. It is not suggested that the absence of the requisite bacterium is always the cause of failure, because it must be recognised that a legume may fail owing to adverse climatic or soil conditions, drought, unfavourable soil reaction, poor seed, animal depredations and other causes. But if a legume is to have a fair chance of success it is not only important that the specific bacteria be present but that they be present in sufficient numbers.

WOUND-HEALING PROCESSES.

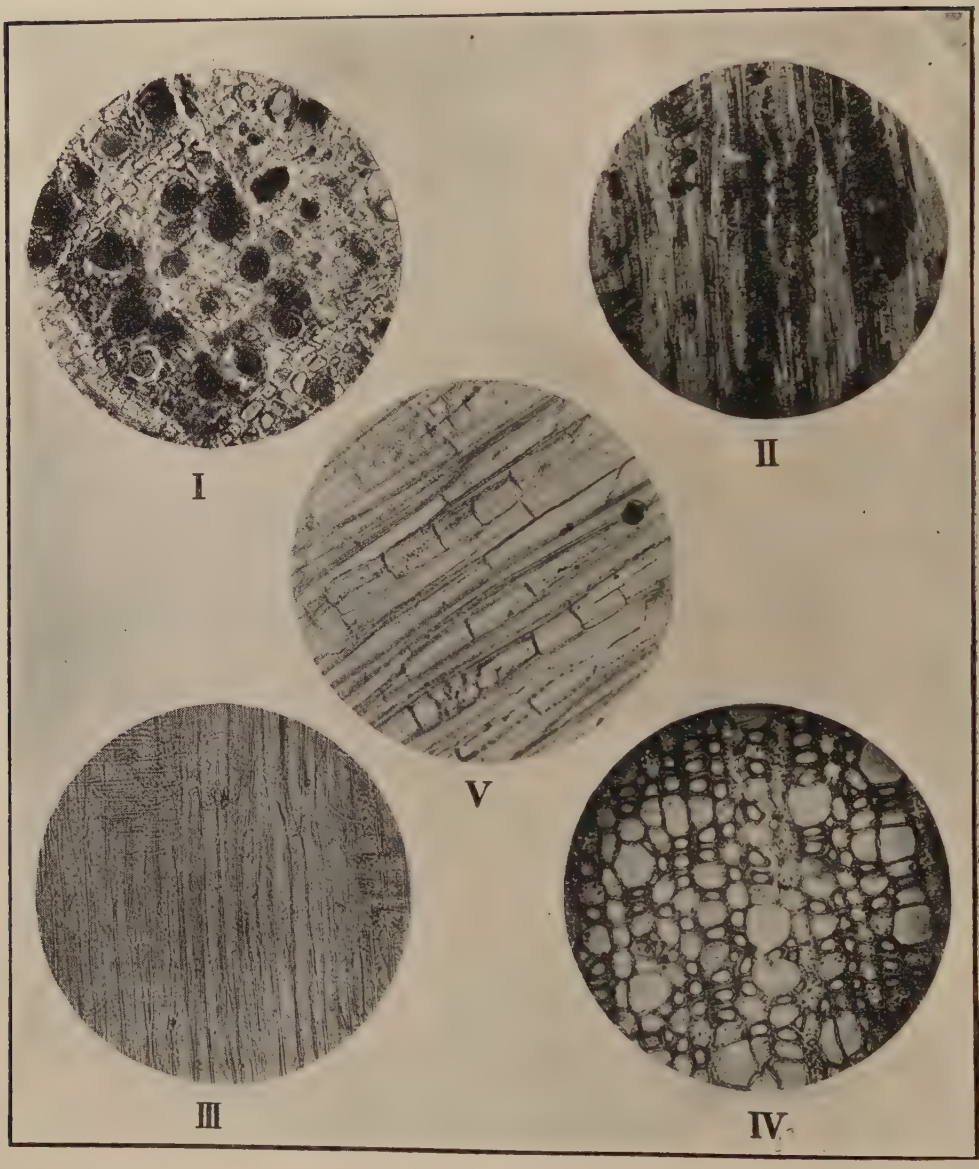
F. R. TUBBS.

It was realised early in the history of forestry that the active growth of callus was of extreme importance in covering the wounds caused by branch removal and thereby preventing the destruction of the timber by wood-rotting organisms. It was observed that the clean removal of the stump of a branch resulted in the wound being buried beneath healthy tissue far more quickly and with the occurrence of fewer cases of woodrot than was the case when a "peg" was left projecting. Later, as timber became more valuable, it became a routine practice of good forestry to disinfect the wound. These operations are every whit as valuable to horticulture as to forestry, and their practice results in similar advantages to the bush.

The importance of the active functioning of the healing processes resulted in further research as the result of which the existence of an additional protection against the entrance of harmful organisms into wounds was discovered. Brooks and Moore [1] found that in the lignified tissues of plum trees a gum was deposited soon after a wound had been inflicted. Formation began in the medullary ray cells and after two days was found to have extended into the vessels. They consider that the gum in the vessels is partly formed from carbohydrates already present, and partly from the products of hydrolysis of the stored food in the medullary ray cells. This process was found to be accelerated by the presence of the fungus *Stereum purpureum* in the wound. Gum formation was found to be the universal reaction to any kind of pathological condition in the plum tree.

Further information was provided by Swarbrick [2] who carried out observations on several species of temperate trees in various seasons. He found that a gum, termed by him "wound gum", was formed in the vicinity of a pruning cut, provided that the cut was not made during a resting season. The amount of gum formed was closely related to the physiological periodicity of the tree, cuts made during the rapid growth season of May to August being quickly blocked, while those made in the autumn were only partially blocked by the gum. During the winter season no gum was formed and it was not until the ensuing spring that the partially blocked autumn cuts and the unblocked winter cuts were protected by gum formation.

Observations upon sections cut in the vicinity of a cut showed a relationship between gum formation and starch loss similar to that already noted. The layer of cells immediately below the cut dried out, starch loss being thereby prevented. A layer below this about


I
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a quarter-of-an-inch in thickness suffered a gradual loss of its starch, which was replaced by a viscous yellow substance, a certain number of colourless globules being formed at the same time. Gum formation occurs in the vessels as well as the medullary rays, it being observed that this process was sufficiently rapid to forestall the passage of fungal hyphae beyond this layer. The gummy material gradually becomes darker and more resistant to chemical change.

Evidence of the completeness of this barrier was found from the resistance offered to the passage of water through the cells. A suction pressure of 70 mm. of mercury applied for 36 hours failed to suck dye through stems in which gum formation had occurred, whereas the dye penetrated through unblocked stems in the course of a few minutes under similar treatment.

It is obvious that this question is of considerable interest in relation to pruning practice on tea estates. Keiller [3] noted that starch disappeared in the vicinity of a pruning cut and that some form of blocking took place. These observations raised the possibility of influencing the abundance of wound gum by cultivation prior to, or at the time of, pruning. Before initiating such experiments, it was necessary to discover whether the observed changes did actually lead to the formation of a "wound gum" beneath the pruning cut. By the courtesy of Mr. Swarbrick, microscope slides illustrating the formation of gum in apple and plum stems were received by the Tea Research Institute, which desires to record its thanks for this assistance.

Photomicrographs of these sections are shown in Figures 1, 2, and 3. The gum is clearly visible in Figures 1 and 2 which are transverse and longitudinal sections of plum and apple respectively. None is to be seen in Figure 3 which is from a region of about three-quarters-of-an-inch below the pruning cut. This illustrates the local nature of the deposit. With these may be compared Figures 4 and 5 from tea wood two months after pruning, in the region in which wound gum would be expected. No deposit similar to wound gum as described by Brooks and Moore and by Swarbrick can be detected.

Swarbrick suggests that in trees where wound gum has been observed in addition to the formation of a soft exuded gum on the bark where attacked by disease organisms, the two gums may be initially of the same nature, but that the former undergoes later a lignification process. In this connection it may be noted that the Institute has no record of external gum formation in tea. It is possible, therefore, that the metabolism of the tea bush does not normally permit of the formation of such materials, although wound

gum is recorded by Tunstall [4] as being formed in small quantity. The reasons for this inability are somewhat obscure, but the distribution of reserve carbohydrates in the tea bush provides a partial explanation. In the tea bush the major portion of the reserves is located in the roots, the stems containing relatively little starch. This difference is even more marked in the plucked bush than in a rested bush or seed-bearer, the removal of flush causing a diminution in the amount of locally stored reserves. The dependence of wound gum formation on starch reserves has already been noted, and it may be concluded that the relative scarcity of the latter is prejudicial to gum production.

It may be noted, however, that a re-distribution of materials similar to that observed by Swarbrick actually takes place. Investigations here show that where starch is present, it diminishes in quantity near the pruning cut, as noted by Keiller. A similar effect occurs with the alcohol soluble material. Samples drawn from a clean pruned field three-and-a-half months after pruning showed the following amounts of material soluble in 85% alcohol, expressed as a percentage of the dry weight.

(1) 5·05% in the $\frac{1}{8}$ in. next to the cut.
(2) 4·50% in the $\frac{1}{2}$ in. next below (1).
(3) 4·76% in the $\frac{1}{2}$ in. next below (2).
(4) 5·47% in the $\frac{1}{2}$ in. next below (3).

This distribution is what one would expect on the hypothesis that the uppermost layer dried before translocation took place, while in the lower a partial mobilisation or transformation of materials had occurred.

The question may be raised as to whether gum may be formed only at certain seasonal periods in the tea bush. This was tested by examining cuts ten months and four-and-a-half years old. In neither case was gum seen.

The method of testing by means of dyes was also used, contradictory results being obtained. In some cases dyes moved easily through the region of the pruning cut, while in others resistance was offered to their passage. As gum cannot be directly demonstrated, one cannot postulate its presence as an explanation of the latter cases. It is possible that the formation of air locks may play a part, while since the existence of a certain amount of chemical change has been shown, it is possible a certain amount of change in the structure of the cell walls may take place [1].

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THE DISTRIBUTION OF BRANCHES AND FLUSH WITHIN A TEA BUSH.

F. R. TUBBS.

The growth of an uncultivated plant from seed to maturity is accompanied by definite and often characteristic changes of form. Tea seedlings, for example, first produce long straight stems which later bear lateral branches at varying distances above the ground level. The more crowded the stand of seedlings, the longer is lateral branching delayed, but given sufficient space for lateral growth, the young tree soon assumes the form of a pyramid. This is due to the fact that the central leader is "dominant" over the lateral branches born upon it, and always surpasses them in height unless its further growth is delayed by injury.

The various methods of pruning adopted to maintain the bush in a shape and size conformable to economic demands act by preventing the bush from attaining too great a height and by attempting to prevent the centre of the bush dominating the outer branches. In other words, pruning and plucking operations are devised to ensure a more equal distribution of growth over the surface of the plucking table. The methods employed are various. The dome-shaped surfaces of a bush towards the end of its cycle is once again reduced to the level surface of a pruned bush, while certain types of pruning seek to encourage the growth of the branches situated near the edge of the bush; in addition during plucking the operation of breaking back is devised to keep the bush level as long as possible.

These methods are, however, only partially successful. Even as early as the tipping stage, more shoots per unit area are produced in the centre of the bush than in areas nearer the edge. This may be observed either on a bush in the tipping stage or by cutting across a bush about three inches above the level of the previous clean prune. This cut being below the tipping level the shoots made at this level at tipping and subsequent to it are exposed to view.

To facilitate an examination of such questions, a wire gauge was made composed of concentric circles having radii of six inches, twelve inches and eighteen inches. This, when laid upon the pruning surface, enabled counts of the number of branches within each zone to be made. From these data the mean number of branches per square foot (or "branch intensity") in each zone could be calculated. The results obtained from a total of 60 cut across bushes show that the branch frequency was highest in the centre zone and fell as the distance from the centre increased. The mean for each zone A (centre) to C (periphery) was:—

A.	B.	C.
22·7	14·9	3·3 branches per square foot.

It would be expected that if this phenomenon is to be ascribed to the tendency of the bush to grow more rapidly in the centre of the bush, the distribution of flush on the plucking table would parallel that already described for tipping shoots. This expectation is borne out by the following figures for number and weight of pluckable shoots per square foot, obtained from 30 bushes 2 years old from clean pruning:—

Zone.	A.	B.	C.
Number of shoots per sq. ft.	5·0	4·1	2·4
Weight of shoots per sq. ft.	0·743	0·536	0·291 grms.

Cohen Stuart, in Java, found that the mean yielding intensity over the whole of the plucking surface is smaller in large bushes than in small bushes. It would appear therefore, considering yield alone, that a large number of small bushes is preferable to a smaller number of large bushes having the same total plucking area. Since, however, the spacing of tea is fixed in all but future clearings, the question arises whether the reduction of average yielding intensity in large bushes is sufficiently great to nullify the effect of the enhanced plucking area. Judging from Cohen Stuart's results, it appears that large bushes yield more than small bushes, though the increase in yield is not proportional to the increase in area of the bush. In 1920, a correlation of $0{\cdot}683 \pm 0{\cdot}021$ was found between the area of the plucking surface and the yield of flush. In 1924 a correlation between area of the pruned bush and the subsequent yield of flush of $0{\cdot}626 \pm 0{\cdot}019$ was found. Thus in general large bushes yield more than small ones.

Since a large pruning area implies a large plucking surface later, the influence of the type of pruning upon the radius of the pruned bush is of interest. The mean radius of sixty bushes each for three types of pruning show that clean pruning results in a definite reduction in the radius of the bush compared to rim lung pruning and cutting across. The values obtaining were 1·35 feet, 1·74 and 1·63 feet respectively. The difference between the latter two types is not statistically significant.

The number and distribution of the branches within the bush is also considerably altered by the type of pruning. The mean number of branches at the pruning surface in clean pruned bushes was found to be 14·0 compared to 22·2 in the case of rim lung and 70·0 in the case of cut across bushes. The distribution of the branches is shown in the following table, giving the branch frequency in each zone:—

Zone.	A.	B.	C.
Cut across	22·7	14·9	3·3
Rim lung	5·9	3·3	1·6
Clean Prune	4·1	3·3	0·7

The effect of the latter types is to produce a much greater reduction in branch intensity in the centre than in the outer zones. In other words they tend to even up the distribution of branches within the bush.

TEA MACHINERY.

THE McKERCHER C. T. C. ROLLER.

R. V. NORRIS.

Messrs. Marshall, Sons & Company have recently placed on the market a new type of rolling machine known as the McKercher C.T.C. machine which seems to possess many points of interest, though details of its performance have not been received by the writer.

The machine consists essentially of two rollers of chromium stainless steel, each 48 in. long and 5 in. in diameter, driven by separate belts and set one above the other as in an ordinary mangle. The top cylinder is driven at 600 revolutions per minute while the lower one can be adjusted to rates between 60 and 100 R.P.M. to suit different qualities of leaf. The rollers are serrated and fluted in such a way that each fits into the other as it works round. The rollers rotate in opposite directions and the leaf is fed by a spreading arrangement on to the slower moving roller. The leaf is carried up by this and is nipped between the two rollers before being discharged. The nip is said to be so strong and instantaneous that the leaf is torn and distorted and practically all the cells are ruptured. As it passes from the roller the leaf expands again and takes up all the juice so that none of the latter is expressed. Moreover, the action being practically instantaneous, there is no development of heat. The machine requires about 4 to 5 H.P. and, it is estimated, two units would serve for a crop of 400,000 lbs. or three for a crop up to 1,000,000 lbs.

It is understood that the method of working in India is as follows. The leaf is first rolled in an ordinary roller without pressure and then sifted. The fine bulk is then put through the C.T.C. machine and again sifted. The leaf passing through the sieves is at once fermented while the residue is put again through the C.T.C. machine, resifted, and this process repeated until all the leaf passes through the sifter. In the meantime the coarse bulk from the first roll is again rolled in an ordinary roller, and the rolled leaf then put through the C.T.C. roller and sifter until it all passes through the sifter when it is fermented and dried in the ordinary way.

The essential improvements claimed are that there is no production of heat, uniform fragments of leaf are produced during the green stage and, the sap being thoroughly expressed and smeared over the leaf surface, an even and rapid fermentation is obtained. Grading of the fired tea is simplified, grading percentages being adjustable to

requirements by altering the size of mesh on the green leaf sifters. The bulk of the tea after firing is passed through a small grading sifter near the drying machine and at once stored in the bins.

The process generally is said to result in strong and coloury liquors.

The price of the machine is, we understand, about £585 f.o.b. English ports. A considerable number of machines has been installed in North India and further details as to their working are being sought.

GREEN MANURING IN RELATION TO ARTIFICIAL MANURING*

T. EDEN.

The suggestion that I should speak to-day on the subject of Green and Artificial Manures involves a very wide field for one lecture. I have therefore narrowed the field of enquiry down to what I believe is the most vital question at present, namely the economical use of both in times of difficult budgets.

We are continually being asked how the manure bill can be reduced without bringing about a lasting deterioration of the soil, and consequent harm to the tea, and particularly whether, in view of the prevailing practice of green manuring, artificials can be omitted entirely. On more than one occasion, it has been suggested to me that the text book idea that green manures provide large quantities of plant nutrients is not strikingly supported by observations spread over quite considerable periods of time. In order to clarify the position it will be necessary for me to describe to you step by step the stages in the process whereby the nutrient substance of green manures becomes available to the plant and to contrast them with the process of artificial manuring.

ARTIFICIAL MANURES: INCOME ON CURRENT ACCOUNT.

To take the simplest case first let us consider the question of artificial manures. A good artificial manure, balanced in respect of nitrogen, potash and phosphate, is, so to speak, a source of income to the soil and the plant. Year by year it is spent more or less up to the hilt, and when the next year's estimates are prepared it is safe to say that most of the manure that has not shown itself in crop-production can virtually be written off as a bad debt.

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* Based on an address given to the Dolosbage-Kotmale Planters' Association.

This is particularly the case with nitrogen. Phosphate and potash manuring in excess of what the plant is able to use may remain to exert a delayed beneficial effect. If we are speaking in terms of manures which contain from seven to twenty per cent. of nitrogen, the chances of a residual effect under our climatic conditions are small even for the so-called "organic artificials", for even the "organic artificials" are rapidly decomposable into simple forms liable to loss in drainage. In my annual report for the current year I shall publish figures for an accurate experiment which shows that in this year of severe S. W. Monsoon rainfall, nitrogen supplied in the form of bloodmeal has been dissipated as completely as nitrogen in the form of sulphate of ammonia, judging by crop records.

In the light of the foregoing we can look upon artificial manures as being predominating concerned with current account, in which circumstances increase of income is felt immediately or nearly so.

GREEN MANURES: MAINLY DEPOSIT ACCOUNT.

The case of green manures is markedly different and is less easily dealt with. In drawing up a balance sheet for green mnnures there is relatively little to enter under the heading of income. A leguminous green manure by virtue of the bacteria in its root nodules is able to fix atmospheric nitrogen, and to that extent the green manure taps a real source of income. Nevertheless, although I know of no accurate experiment under tropical conditions from which one can assess this income, there seems little doubt that its potentialities are markedly less than under the conditions of temperate agriculture. From this it follows that a large part of the nitrogen, in all probability the largest part, and all the potash and phosphate, that is built up into green manure tissue comes from the soil reserves.

When therefore green stuff containing say 50 lbs. of nitrogen is forked into the ground it does not supply 50 lbs. of *new* nitrogen; on the other hand when 50 lbs. of nitrogen in the form of an artificial fertiliser is used it *does* supply 50 lbs. of perfectly *new* nitrogen. Before we consider what possible benefit this withdrawal of nutrients from the soil, and out of the range of the tea bush, and its return, can confer upon the tea, it will be well to pursue the subject a stage further. When a green manure crop removes 50 lbs. of nitrogen from the sphere of action it is impossible practically to put the whole of that 50 lbs. back again. The nitrogen is distributed in roots, leaves and woody tissue, but it is not evenly distributed. The concentration of the nitrogen is greatest in the leaves which contain on the average as much as 3%. In the wood the value falls to less than 1%. Since however the trunk of a shade tree remains, and the woody parts of the toppings are discarded, even though they contain

only a small *per cent* of nitrogen, the absolute gross quantity discarded is appreciable, and I doubt whether the balance is ever completely redressed by the income from nodules. Bush and cover crops have an advantage from this point of view because the proportion of woody tissue discarded is less, but the fact remains that there is never likely to be a hundred per cent. return of "borrowed" nitrogen or "nitrogen on deposit" to the soil.

THE RETURN OF NITROGEN TO THE SOIL AND TO THE PLANT.

We must now consider what happens to the green manure when it is forked in, and what share the plant gets of the temporarily hoarded store. The amount which, on decomposition, becomes readily available to the plant depends not only on the quantity of total nitrogen available, but on just how that nitrogen is locked up. I have referred to nitrogen discarded in woody tissues. For reasons that I now outline, it would be injudicious to try and return more nitrogen by using such tissues in addition to the leaves and young stems.

The nitrogen in green vegetable tissue is not immediately available to the growing plant until it has undergone a series of decomposition changes. These changes are brought about by fungi and bacteria. These organisms are not however complete philanthropists; they decompose the vegetation in order that they may live and grow, and they must be served first. It is only what is left after their appetites are surfeited that the plant can use. In their search for foodstuffs the micro-organisms use predominantly two types of food, carbonaceous food such as sugars, cellulose, and starch, and nitrogenous food such as proteins. Their growth in the first place seems to be conditioned by the carbonaceous resources and if that is present in quantity the micro-organisms reproduce themselves rapidly. There is seldom any scarcity in that direction when green manures are forked in. Side by side with their use of carbon is their employment of nitrogen. Sooner or later one of these sources gives out and a period is put to the microbial multiplication. If the carbonaceous matter is exhausted the quicker, all is well, for the excess of nitrogen is then in a form easily accessible to the plant and is so used, If however the nitrogen is exhausted first the organisms turn elsewhere for their nitrogen, and find it in the soil nitrates which normally feed the plant. The result is that the only readily assimilable supply of nitrogen available to the plant is commandeered by the organisms, and is only released when their multiplication ceases and death ensues. This locking up of nitrogen is a well-established fact, and the temporary nitrate starvation it produces can have very serious effects on the crop.

Micro-organic activity can therefore be either good or bad, depending on the relative levels of carbon and nitrogen in the green manure. The critical balance is established when about 2% of nitrogen is present in the buried tissue. Values below that mean that the carbon content is correspondingly high, and no available nitrogen is produced; that in addition, soil robbing may occur. Values above 2% indicate that the processes of decomposition will release the excess over 2% for the benefit of the crop.

It should now be fairly clear that if one considers only one cycle of the whole process, green manures grow, they batten on the soil for supplies to a considerable extent, all that they extract cannot be returned, and of what is returned, only a portion is rapidly available to the crop. It explains why the often quoted statement that the green manure crop supplies so many attractive looking pounds of nitrogen, etc., is definitely misleading, because to reiterate the fundamentals it is *not new nitrogen* and it is not all readily available.

All this seems rather black for green manures but we have looked at one side of the picture only so far. There is the steady inevitable drain of soil nutrients from the soil in drainage losses. Only a proportion of added manures ever produces crop. In a temperate country such as England, at Rothamsted where the rainfall is only 29 inches, it requires 86 lbs. of manurial nitrogen, plus soil supplies, to give a crop of wheat containing 50 lbs. of nitrogen; only 60% of the manure is used, and the rest is a dead loss. Despite all that has been said, it is this aspect of the question that green manures bear on. In so far as they make use of nitrogen otherwise lost in drainage they conserve the soil nitrogen supply; they prevent the waste of income; they recapitalise a proportion of it, some to be decapitalised shortly after burying, some to remain on deposit and make a small but not negligible return almost continuously. So long as that deposit remains intact, locked up with carbon, it cannot be lost in drainage, and it represents a comfortable bank balance on which to draw when normal income decreases, or when adverse circumstances, such as weather, wastefully dissipate fluid supplies. The process goes on continually, always withdrawing, always supplying, always conserving.

The capital supply of nitrogen formerly given for tea culture by the forests of Ceylon is being depleted at a considerable pace by the burning up of soil organic matter by oxidation process hastened by cultivation. The only hope of slowing it down is by green manuring. You cannot conserve nitrogen unless you conserve carbon too. Fortunately the green manure manufactures carbon compounds from the carbon-dioxide of the air. That is the master key to the whole situation.

No more striking confirmation of this is needed than forest soil itself. Before the advent of vegetation there was assuredly little difference in the nitrogen content of different soils. Forest soils have kept their nitrogen because it has been absorbed by the trees, combined with carbon and returned to the soil as leaf mould.

PRACTICAL APPLICATION.

I have dealt at length with the green manure cycle because the aspect I have described is to my mind the most important nutritional aspect in tropical agriculture. In what follows I shall deal with a few selected and specific points.

An estate with a through green manuring programme is husbanding its soil nitrogen supplies and will consequently be in a better position to weather the economic storm. Whilst it follows that the total cessation of artificial manuring will progressively curtail the nutrient supply to the crop, the decline will be less severe than where no such programme is in operation. One cannot recommend the dropping of artificials *entirely* even with a green manure programme; but any curtailment is likely to be of a less permanently harmful nature than in the absence of green manures.

From what I have said, the success of forking in green manures is seen to depend largely on the composition of the green stuff at the time it is used. The older the vegetation used, the smaller its nitrogen percentage composition. Thus to leave a crop to grow to large dimensions may result in a low nitrogen content which was seen to be inadvisable. As a general rule green manures should be lopped before full flowering, as after that the nitrogen is withdrawn to the seed; woody tissue is to be avoided always.

Despite certain practical obstacles there is much to be said for forking in green manures and artificials together. The nitrogen contained in the latter helps to stimulate the vegetable decomposition. If the nitrogen content of the green stuff is unavoidably low it also helps to bring up the general level above that critical 2% and to prevent soil robbing. Even though some of the artificials are thus temporarily locked up they are saved from drainage losses and will come into action later. For a similar reason the use of artificials of an inorganic type in conjunction with green manures raises part of them to the category of "organic artificials" which are unit for unit so much more expensive.

In conclusion, whilst I have purposely avoided any reference to the benefits that accrue from the use of green manures as improvers of the physical state of the soil, that is an aspect of equal importance and is another argument for the prosecution of a far reaching green manure programme.

TEA SAMPLES FOR REPORT.

D. I. EVANS.

(1) *Moisture.*—The only way of deciding whether tea is properly fired or not is by determining the actual moisture in the tea, and many estates have sought the help of the Institute in this matter. The moisture content of 348 samples of tea was carried out for estates during January-February this year, and many driers examined and reported upon. In view of the importance of the question of drying, a good deal of work is being done to investigate this problem, and data are being gradually collected concerning most of the different types of driers in use. The determination of moisture in tea samples for estates is considered as a part of the investigation, provided that the estates concerned are willing to co-operate by supplying certain information along with the samples. The Biochemical division cannot, however undertake to carry out routine moisture determination for estates unless such work adds something to the sum total of our knowledge of tea manufacture. All samples sent to the Institute for moisture determinations should be in a airtight tins and not in lead packets, since tea lead is not devoid of small holes and therefore not impervious to moisture. Every tin should be plainly marked with the name of the estate, as well as a description of the tea it contains. This is very important when the samples and accompanying letter are sent under separate cover. If the samples are sent under a different mark from that of the estate name, this should be referred to in the letter, but to avoid confusion, the sample tins should be marked with the name of the estate as on the covering letter. Every sample should also be accompanied by the following information:—

(1) The object of the moisture determination.

(2) Type of drier in use.

(3) Load on tray or the output per hour of the machine.

(4) Degree of wither.

(5) Firing temperature, i.e., inlet and exhaust temperatures.

(6) Time it takes the fermented leaf to pass through the machine.

(7) Fan Speed.

If the information asked for above is accurately determined and sent along with the samples, valuable information of general interest will be collected as a return for the work involved in carrying out the

moisture determination. On the other hand, neglect to send the information results in the accumulation of hundreds of figures which convey nothing to anybody but the estate manager in question. Again a full knowledge of the drying conditions very often puts the Institute in a position to give advice along with the report on the moisture content.

In the meantime a good practical set for moisture determination is being sought, and it is hoped that the Institute will very soon be in a position to recommend a serviceable set for this purpose. The set which is now on the market is not favoured, since I do not consider the balance suitable for estate use.

(2) *Samples for tasting.*—The Institute does not undertake to report on teas, since that is done very much better by professional tasters on whom the Institute also relies for reports on their teas, both commercial and experimental. Tasting of samples has been done once or twice in the past, but the number of samples sent in is becoming so great as to tend to turn the department into a tasting and not a research section. Estate managers will, therefore, please note that *tea samples should not be sent in for tasting and report.*

If the above instructions are followed enquirers will greatly facilitate the work of the biochemical division of the Institute.

THE FIRING OF TEA.

(REVIEW.)

An interesting article by Mr. C. R. Harler, dealing with the firing of tea in North-East India, appeared in the Quarterly Journal of the Indian Tea Association (*Quarterly Journal, Indian Tea Association*, 1930, 66-74). In view of the great attention which is now being paid to the question of the proper firing of the tea in Ceylon it is appropriate to bring the contents of this article to the notice of planters in general.

Harler explains that firing inactivates the Yeasts, and other Micro-organisms present in tea, and checks the loss of soluble matter which takes place during fermentation. Firing does not stop all chemical changes, since some changes which result in the mellowing or maturing of tea still proceed in the dry tea.

Some aroma is lost during firing, especially if there is any stewing of the leaf.

The drying of the tea should be carried out gradually, so that moisture is removed from the surface of the fermented leaf at the same speed as the moisture will travel from the centre of the leaf to its surface. In modern tea driers this is attained by submitting the moist fermented leaf to a blast of comparatively moist, warm air to start with. The partly dried leaf then travels into a region where it meets with progressively hotter and drier air so that an even drying of the leaf results. Harler points out that if the bye-passes fitted to some driers are open, then dry hot air passes direct on to the moist fermented leaf and case-hardening of the tea occurs. In the experience of the writer this is only too true, and, in passing, I should like to point out that in my opinion these bye-passes are not only detrimental and wasteful of heat but also useless. In many cases the hot air does not actually come in contact with the leaf at all but it escapes along the edges of the top trays, thus wasting heat. This is the case with a tilting tray machine as anybody can test if only he determines the temperatures near the edges of the top tray.

Fermentation should be stopped as quickly as possible once the fermented leaf enters the drier, otherwise flat teas will be obtained as a result of stewing. If the temperature just above the top tray is about 100°F flat teas are obtained, but if the temperature is about 120°F the teas will keep their pungency and briskness, and there will be no loss of tannin bodies during firing. The temperature below the top tray must be about 140°F in order to get a temperature of 120°F above the leaf on the top tray. The temperature of the leaf should then increase steadily through the machine.

It is necessary to heat tea to a temperature near 170°F otherwise it will not keep in storage, and it is suggested that 180°F should be

the minimum temperature of firing for North-East India. It is pointed out, however, that temperatures as low as 200°F have given teas with a "touch of fire" when dry teas are submitted to this temperature, and dry teas kept at 180°F for half-an-hour are reported as being "dry" although they do not exhibit high firing characteristics. Higher temperatures than 180°F result in loss of quality, but in rush periods it is preferable to raise the initial temperatures to 200°F or even more to discharging tea with a high moisture content, or allowing the exhaust temperature to drop below 120°F.

If the machine runs empty then the temperature of the exhaust air will rise, and it is advisable to reduce the time of fermentation of the next dhool so as to prevent a gap if possible. If the moist leaf meets a temperature of around 140°F it will be case hardened, and it will have poor keeping qualities.

Tea is liable to pick up moisture once it has been fired, especially during the storage operations. The moisture content may rise to 7 or 8 per cent, and tea with such moisture content should be final fired before it is packed. The final firing should be carried out between 120° and 150°F but it is very important that the tea is not dried too far. Observations made at St. Coombs indicate that Harler has even under-estimated the amount of moisture which tea can pick up after firing, as will be seen from the following figures in Table I.

TABLE I.

Moisture Contents of tea after firing.

	% Moisture.
After firing	2·73
Next day before sorting	4·7
B.O.P. after sorting	6·4
B.O.P. for packing	7·6
Flowery Pekoe after sorting ...	5·7
,, ,, for packing ...	9·1

The question of absorption of moisture by made teas has been well treated by Deuss, and reviewed in this Journal (*Tea Quarterly*, 1928, **1,**) by Mr. Petch. The existence of this article seems to have been overlooked by planters in general, but I suggest that a search for it in the earlier numbers would be well worth the trouble.

In a previous article on the "Factory requirements for the making of good tea" (*Quarterly Journal, Indian Tea Association*, 1929.) Harler points out that the capacity of firing machines given by the makers refers to working temperatures of 210-230°F. Since it has been found that a firing temperature of 180°F is the most satisfactory as far as quality of the tea is concerned, firing machines working at the lower temperature have not the capacity stated by the

makers. The capacity can be increased by speeding up the fans, but the net result is a capacity somewhat lower than that rated. The drying capacity of a machine varies as the square of the fan speed, and it is safe to increase the fan speed a little above that stipulated by the makers.

In considering these two articles it must be borne in mind that firing practice in Ceylon differs from that in North India in two important respects: (a) Harder withered leaf is used for rolling and fermenting and (b) Firing is carried out in one operation in Ceylon.

These differences, however, are quite immaterial when the capacity of the machines is stated in terms of moisture evaporated per hour. From this point of view the above statements are applicable to Ceylon conditions, and the results of my investigation of a good number of drying machine supports Harler's conclusions which are summarised below:—

(1) Tea must be heated to a temperature near 170°F if it is to have good keeping qualities.

(2) The optimum temperature of the inlet air should be 180°F; in my opinion this can be increased to 195°F.

(3) The temperature of the exhaust air from a drying machine should be 120°F.

(4) Teas should leave the drier with 3 per cent of moisture and be packed with 6 per cent of moisture. In this connection teas may be turned out with 4-5 per cent moisture in Ceylon during the dry weather season when flavour is the most important factor, but in the wet weather 3 per cent should be aimed at.

(5) Dry teas absorb moisture very quickly during sorting.

(6) Teas containing more than 6 per cent moisture will not keep well.

(7) Teas containing more than 6 per cent of moisture should be final fired before packing.

(8) Final firing should be carried out between 120° and 150°F, but the tea should not be dried too far, otherwise it will not mature properly.

(9) Firing machines in general have not the capacity claimed for them by the makers, but this capacity can be increased by speeding up the fans to a certain extent.

(10) If the inlet temperature of the drying machine is fixed at 180-195°F, the load on the machine, and the time it takes the leaf to pass through the machine must be so adjusted that the exhaust temperature is 120°F and the *tea turned out contains 3-4 per cent of moisture.*

D. I. EVANS.

THE GREYING OF TEA.

(REVIEW.)

Greying of Tea.—This aspect of tea manufacture is dealt with by Benton in *The Quarterly Journal of the Indian Tea Association* for 1931.—(*Quarterly Journal, Indian Tea Association*, 1931, Part III, p. 139), Benton states that a small fraction of the light falling on to a particle of dried tea may be reflected in any direction. The greater part of the light is absorbed so that fired tea presents a shiny black appearance. Greyness of tea is the result of an increase in the amount of light reflection, and this result is obtained in several ways during the treatment of the tea manufacture.

One type of greyness is obtained by any treatment which results in rubbing the surface of the leaf. If cutting and sorting is carried out directly the tea leaves the drier, greying will occur. Greyness is also obtained if the particles of the tea are allowed to rub against each other. This action may be produced during sorting and cutting if the tea forms a moving mass in the hopper or remains for any length of time on the tray of the sifter. The tray of the sifter should therefore not sag, otherwise tea will remain longer than necessary in the hollows and will be greyed. The cutting edges of the cutters should be kept sharp, and the cutters should not turn at too high a speed.

A certain greyness may be produced as a result of rubbing the fine hairs off the underside of the bud and the finer leaves. If these adhere to the coarser leaves a dull bloom is produced on the tea, and a golden coloured tip is not obtained. High rolling speeds are liable to destroy tip, but 55 r.p.m. is considered suitable for the first roll. If too small a quantity of fine leaf is removed in the first roll tips will be carried on to the second roll and subjected to pressure, resulting in loss of tip and greying of tea.

Another form of greyness is the result of firing conditions which lead to case hardening of tea and the development of small blisters on the surface of the leaf. If the tops of these small blisters are rubbed off during sorting etc., greyness of the tea is produced.

D. I. EVANS.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON.

A meeting of the Board of the Tea Research Institute of Ceylon was held in the Ceylon Chamber of Commerce, Colombo, on Friday, the 5th February, 1932 at 2-15 p.m.

Present.—Mr. R. G. Coombe (Chairman), the Director of Agriculture, Major J. W. Oldfield, O.B.E., M.C., M.S.C., Messrs. A. G. Baynham, G. K. Stewart, J. A. D. Finch Noyes, John Horsfall, C. C. du Pré Moore, A. W. L. Turner (Secretary), and by invitation Dr. Roland V. Norris, D.SC., F.I.C., (Director, T. R. I.).

Absent.—The Hon'ble the Financial Secretary, Mr. D. H. Kotalawala, M.S.C., Major H. Scoble Nicholson, O.B.E., and Mr. C. H. Z. Fernando.

1. Notice calling the Meeting was read.

2. Minutes of a Meeting of the Board of the Tea Research Institute of Ceylon held on the 23rd October, 1931, were confirmed.

Letters and telegrams regretting inability to be present at the Meeting were received from the following Members: the Hon'ble the Financial Secretary, Mr. D. H. Kotalawala, M.S.C., and Major H. Scoble Nicholson, O.B.E.

3. MEMBERS OF THE BOARD, T. R. I.

On the proposal of the Chairman, votes of thanks were recorded for services rendered by the Hon'ble Mr. D. S. Senanayake, M.S.C., the Hon'ble Mr. T. B. Panabokke, M.S.C., and Mr. R. D. Morrison whilst serving on the Board of the Institute.

The Chairman announced that the Low-Country Products Association had elected Mr. C. H. Z. Fernando in place of the Hon'ble Mr. D. S. Senanayake who had been a member of the Board since the 31st October, 1928. His Excellency the Governor had nominated Mr. D. H. Kotalawala to represent the small-holders vice the Hon'ble Mr. T. B. Panabokke, who had been a Member of the Board since the Institute was founded in 1925; and Mr. G. K. Stewart had resumed his seat on the Board vice Mr. R. D. Morrison who acted for him.

He also announced that Mr. C. C. du Pré Moore had been elected by the Planters' Association of Ceylon to serve on the Board during Mr. Jas. Forbes' absence on leave.

4. FINANCE.

(a) *Statement of Accounts as at 31st December, 1931,*—which had been sent to each Member of the Board prior to the Meeting was discussed.

After a general discussion, Mr. Finch Noyes proposed and Major Oldfield seconded that the Accounts be adopted. This was carried.

The Secretary tabled an abbreviated form of Analysis of Expenditure, the adoption of which would result in considerable savings.

This was approved and in future the monthly statement will be issued in this form.

5. ST. COOMBS ESTATE.

(a) *Visiting Agent's Report dated the 28th November, 1931.*—This report was sent to each member of the Board under cover of Circular No. A. 31/32, dated the 3rd December, 1931. No comments were made.

The Chairman said that instead of publishing the official report, he had asked the Visiting Agent to write a special review on the estate for inclusion in the Annual Report. This proposal received the approval of the Board.

(b) *Bungalows.*—The Chairman stated that he had inspected the work on the two new senior staff bungalows and good progress was being made.

The Director expressed himself as satisfied with the quality of the work.

6. SENIOR SCIENTIFIC STAFF.

(a) *Mr. T. Eden, Agricultural Chemist.*—Announced that Mr. Eden proceeded on 9½ months' leave on the 16th December, 1931.

(b) *Dr. D. I. Evans, Biochemist.*—Announced that Dr. Evans returned from leave on the 21st December, 1931.

7. JUNIOR STAFF.

(a) *Field Assistants.*—Announced that Mr. I. R. Nicol was appointed second field assistant to the Plant Physiologist as from the 4th January, 1932. The appointment was confirmed.

(b) *Mr. B. N. Sastri, Assistant to the Biochemist.*—The Director said that with his permission, Mr. Sastri had applied for an Assistantship in the Biochemistry Department of the Indian Institute of Science, Bangalore, and had been duly appointed.

Mr. Sastri wished to take up his new appointment as from the 1st April, 1932. It was decided to accept Mr. Sastri's resignation with regret and to relieve him of his duties as from the 31st March, 1932.

In this connection, the Director proposed that instead of appointing a Research Assistant in place of Mr. Sastri, two Junior Assistants should be appointed. The matter had been discussed with Dr. Evans

and both he and Dr. Evans were of opinion that the work of the section would be facilitated by this change, which would also lead to some saving under salaries during the next few years.

In reply to Major Oldfield, the Director said that arrangements for housing could be made as the new Assistants would share one bungalow.

After some discussion it was decided to appoint two Junior Assistants. It was also decided that in all new appointments the officers appointed should be required to become efficient in both Tamil and Sinhalese.

8. PROVIDENT FUND OF THE JUNIOR STAFF.

Announced that during the absence of Mr. Jas. Forbes (Jnr.) on leave, Mr. Baynham had agreed to act as one of the Trustees.

9. NETTLE GRUB.

It was announced that Nettle Grub had been declared a Pest in the Province of Uva.

10. SMALL-HOLDERS.

The Director said that thanks to the Director of Agriculture, he had been able to obtain returns as to the number and size of small holdings in tea in various districts. These figures were now being analysed in order that an area might be selected for preliminary work. It was likely that this area would be in the Gampola or Nawalapitiya districts. In these two areas there were some 1803 small holdings but 1513 of these were of less than 5 acres so the problem was not an easy one. There were, however, a few larger holdings which might perhaps be made centres for propaganda work. He hoped to put up more definite proposals at the March Meeting.

With regard to the pruning experiment at Peradeniya, steps would be taken to advise small-holders in the neighbourhood of these experiments and arrangements for demonstrations were under consideration. It might also be possible to make somewhat similar arrangements at Galatura, but there the experiment was being carried out on a private estate.

The Director of Agriculture suggested that vernacular leaflets announcing the experiment might be issued. The Director agreed with this proposal but stated that in regard to demonstration work generally he did not think leaflets would be effective.

The Chairman announced that Messrs. James Finlay & Company had agreed to allow the use of a bungalow, rent free, at Galatura in connection with pruning experiments. He suggested that the Board's appreciation of this action should be conveyed to Messrs. James Finlay & Company, and Mr. J. D. Hoare, the Superintendent.

The Chairman announced that the Experimental and Estate Sub-Committee had met on the 4th February and minutes of the Meeting would shortly be sent to each Member of the Board.

11. PROGRAMME OF WORK.

Mr. Finch Noyes suggested that any information the Research Staff could give on the following items would be appreciated:—

(1) Assessment of the value of Artificial Withering and comparison with Natural Withering.

(2) Utility or otherwise of exhaust fans in rolling rooms, with particular reference to any possible loss of flavour.

(3) Fire-proofing of hessian tats.

(4) Utility of pruning mixtures.

The Director said that Dr. Evans who had recently returned from leave had just commenced a series of experiments on withering and the points referred to would certainly be brought to his notice. In regard to withering tats, arrangements had just been made to carry out tests with fireproofed hessian, particularly in regard to the possibility of taints arising from such treatment.

Some reference to pruning mixtures would be found in the Annual Report for 1931, and this question was already receiving the active consideration of the Staff.

The Chairman said that Dr. Evans' Department had been paying considerable attention to the moisture contents of tea prior to packing. This should be about 6% but much higher figures were frequently found. In future all St. Coombs' invoices were to be tested before despatch.

12. ANNUAL REPORT.

The Secretary's portion of the Annual Report for 1931, was slightly altered and adopted.

13. NEXT MEETING.

It was decided that the next Meeting of the Board should be held at St. Coombs on March 29th at 2-15 p.m. The Chairman expressed the hope that as many members of the Board as possible would reach St. Coombs at 8-30 a.m. and inspect the property and Laboratories. He added that the Senior Staff would do their best to provide accommodation and lunch.

14. CHAIRMANSHIP.

It was decided to leave this matter over until the next Meeting.

The Meeting terminated with a vote of thanks to the Chair.

A. W. L. TURNER,
Secretary.

NOTICES.

The Institute's Laboratories are situated at St. Coombs, Talawakelle, and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station c/o Messrs. Hemachandra & Co., Forwarding Agents.

Visitors' Day.—The first Wednesday in each month has been set aside as Visitors' Day at St. Coombs Estate, when it is hoped anyone interested will visit the Station.

Visitors at other times are welcome but the Staff may not be free to show them round. Such visitors, on arrival at the Factory, are requested to ask for the Teamaker.

St. Coombs Estate is reached by taking the turn-off opposite culvert marked 28/10 on the Nanu Oya-Talawakelle main road. A signpost has been erected at the turn-off.

Publications.—Applications for the Institute's Publications should be directed to the Secretary, at Victoria Commemoration Buildings, Kandy, and *not to the Director's Office.*

It has been decided that advertisements will be accepted for insertion in *The Tea Quarterly.* Full particulars, with details of charges, can be obtained on application to the Director's Office, St. Coombs.

ROLAND V. NORRIS,
Director.

EDITORIAL.

SOIL EROSION.

An interesting discussion on Soil Erosion took place at the March meeting of the Estate Products Sub-Committee, when the Report of the Soil Erosion Committee came up for consideration.

This discussion indicated that there is still considerable difference of opinion in regard to some of the recommendations of the Committee and also some misconception of the measures advocated.

On one point, however, complete agreement was in evidence, namely in the harmful effect of scrapers. It is much to be regretted that this opinion is not more widely reflected in actual estate practice. For, though the use of scrapers is generally denied, it is still a matter of common experience to see such weapons—often of a most vicious type—in use.

One misconception which seems somewhat widely held by those in favour of clean weeding is that the opponents of this system favour the uncontrolled growth of any and every kind of vegetation, grasses included. No justification for this idea can be drawn from the report of the Soil Erosion Committee. On the contrary, it is generally agreed that certain weeds, and certain types of grasses in particular, are injurious and must be eliminated, and the importance of the proper *control* of cover crops has been continually stressed by those advocating their trial. To this it is retorted that such control involves additional expenditure. It is doubtful whether many estates have reliable figures on this point but, *assuming* for the sake of argument that some extra expenditure is involved, it may well be asked whether such expenditure would not fully justify itself. In this connection we would again refer our readers to the article by Mr. George Brown in *The Tea Quarterly*, Vol. IV., page 117.

There is a deep-rooted feeling in many minds that an estate which is not clean weeded is a "dirty" estate, the implication being that such a condition is evidence of general slackness and bad management.

But such an implication really defeats the argument to which it is applied, namely the claim that when such an estate is taken in hand and clean weeded an immediate improvement in the tea is apparent, the whole of the credit for the change being put down to the clean weeding. If the previous condition were due to lack of control it is at least arguable that the improvement was brought about by improved cultivation and organisation at least as much as by clean weeding.

A more valid, though we hope only temporary, argument in favour of clean weeding is that really suitable cover crops are not generally available. But it is particularly to meet this argument that some progressive action is required by estate proprietors. We think few persons will deny that vast damage and loss is caused by soil erosion. Admitting this, is it too much to suggest that estates should set aside small areas for the *trial* of different cover crops ? Were this done on a reasonably wide scale there would soon be available data as to the species most suitable for various districts and the best methods of establishment and control, and information as to the effect, beneficial or otherwise, of particular species on the tea would rapidly be accumulated. Several varieties of cover crops are now being tried out at St. Coombs but it is obvious that the success or failure of any particular variety under the condition prevailing there is no criterion as to the behaviour of such a variety in areas under totally different conditions of elevation and climate. We would, therefore, press most strongly for experiments of the type suggested to be carried out by as many estates as possible, full records, including costing figures, being kept of the experimental areas for comparison with areas not so treated.

Quite apart from the soil erosion aspect of cover crops we would remind visiting agents and estate proprietors, from whom the impulse for such work must originate, of the beneficial effect of such crops on soil conditions generally. Attention has frequently been called to this aspect of the question in the pages of *The Tea Quarterly* but it is desirable again to stress this point at a time of economic depression like the present, when the question of conserving and building up soil fertility is a matter of grave concern to the majority of estates.

It only remains to add that in any cases where such experiments are contemplated the Institute will do everything possible to assist.

MOISTURE IN TEA.

Arrangements have now been completed with Messrs. Baird & Tatlock, Ltd., 14-17 Cross Street, Hatton Gardens, London, E.C. 1, for the supply of a suitable apparatus for the determination of moisture in tea.

The price for the complete equipment (in London) is £6.8.9. For quantities of three dozens the price will be reduced to £5.13.3.; and for quantities of fifty to £5.9.0.

ROLAND V. NORRIS.

THE "NETTLE GRUB" PEST OF TEA IN CEYLON.

(Continued.)

G. D. AUSTIN.

CONTROL.

ARTIFICIAL MEASURES.

MECHANICAL CONTROL.

Hand-picking, or the collection and destruction of both grubs and cocoons is the commonest, cheapest, and most effective measure of control. It has been recommended in the past, and will continue to be advocated as long as labour is reasonably cheap. But, like all other measures of control, it has its limitations. The collection of *grubs* is practical and effective when the pest is described as a "medium attack" or anything less in severity. When grubs are present in thousands, as they invariably are during severe outbreaks, then collecting is a practical impossibility. During such an attack collecting podians would have to devote about an hour to a bush if they were to pick out every single grub. On the other hand, if they were allowed to pick every leaf carrying grubs, the defoliation caused by this measure would be as bad or worse than if the pest was allowed to remain uncontrolled. Collection of grubs is, therefore, recommended when an outbreak is considered slight or medium.

Dr. Hutson [11], the Government Entomologist at Peradeniya, has recently advocated that "collections should be carried on continuously throughout the year when, say, 10 coolies are each getting only 25 to 50 specimens daily from several acres." This recommendation was made by Dr. Hutson because it was his considered opinion that nettle grubs never completely disappeared once they established themselves in a particular area. There is a certain amount of evidence in support of Dr. Hutson's contention in that on two groups of estates the pest has been observed right through the year. The few grubs collected off and on would never have been detected had not podians been out regularly examining all areas liable to attack. A measure adopted recently is the training of estate podians to become familiar with the appearance of all nettle grubs and their different stages. The chief duty of these podians, 6 to 10 in number and in the charge of a reliable kangany, is to be out collecting every day, and practically "comb out" the whole estate at least twice a month. Each podian is equipped with a tin for the collection of grubs and cocoons. When collecting grubs it is expedient to have the tins

smeared with crude oil in order to prevent the caterpillars crawling and dropping out. The day's collection should be shown to the superintendent. Under existing conditions pluckers are invariably the first to detect and report the presence of the pest and by this time the attack is sometimes considerably advanced.

The collecting of *Cocoons* is considered an easier and more practicable measure of control than the collecting of grubs. In fact Green [3] once suggested that the best course to adopt was to wait till the grubs entered the cocoon stage and then commence collecting. Estates which have adopted this method of control report the collecting of bushels or sacks of cocoons per day. What this means can be realised when it is remembered that a sack weighing 25 lbs. would contain about 160,000 cocoons. During the severe outbreaks in Passara in 1928, Hutson [8] records "From a 40-acre field which was heavily infested by *Natada* over a period of nine months it was estimated that a total of at least 75 million cocoons was collected and destroyed during this period. These figures were calculated from careful records of the weight of cocoons collected, allowing an average of 400 to the ounce. In other words nearly $5\frac{1}{4}$ tons of cocoons were collected from the 40 acres during nine months."

The practice of taking the day's collection, in sacks or empty kerosene tins, to the factory or some other part of the estate is deprecated owing to the risk of emerging moths settling down in new fields. All cocoons gathered should be destroyed, once every two hours, by dropping them into a fire, close to the area from which they are collected. Some estates carry a portable incinerator for this purpose.

Nettle grub is now a declared pest* and it is a legal obligation on the part of all superintendents of estates in Uva to report its presence when found and to *collect cocoons*.

PRUNING.

In cases of severe infestation, and if the tea is due for pruning, it is recommended that the affected field be pruned at once and all prunings be buried (if the grubs are very young) or burnt (if the grubs are half-grown or a bit older). Hutson [6] has advised that "pruners should start around the edges of the field and gradually work in towards the centre"; and Green [2] advocated that "a belt of quicklime round the pruned area will help to keep the caterpillars from straying to the surrounding field".

CHEMICAL CONTROL.

Green [1], Rutherford [4], and Hutson [6] have all at one time or another recommended that spraying should be resorted to when the collection of grubs was found impracticable and pruning too drastic

* Proclamation in *The Government Gazette* of 29th January, 1932.

a measure of control. Green and Rutherford both suggested a lead arsenate spray. The former, however, qualified the recommendation by advising its application against the pest in "young tea which was not in plucking" or "immediately after a round of plucking" and that "bushes should be allowed to run from 10 to 12 days before next plucking". Rutherford [4] was more cautious and suggested that if "two or three pluckings were discarded thereafter there would be no danger of arsenate of lead getting into made tea".

In 1919 Jardine [5] recommended the spraying of lead chromate for the control of Tea Tortrix, and as this non-arsenical insecticide was found to have no harmful effect on either the flush or made tea, it was recommended for the control of all caterpillar pests of tea, which, of course, included nettle grubs. Subsequent experiments in Peradeniya showed that this insecticide had no toxic effect on nettle grubs and its recommendation was dropped.

In 1928 Light [7] carried out a series of laboratory tests with Paris Green, lead arsenate, and sodium silicofluoride, with the aim of determining their relative toxicity against *Natada nararia*. He found Paris Green more toxic than the other two insecticides tested and therefore recommended its use against nettle grubs in nurseries and young tea in clearings. All the insecticides hitherto experimented with or recommended were stomach poisons.

In 1929 the writer commenced a series of trials with contact insecticides, the purpose of which was to find some cheap, quick-acting spray which could be applied while the pest was on tea in full plucking. The result [9] of these preliminary experiments was the discovery of soap and water as a spray for nettle grubs.

Field experiments during the last two years have demonstrated that the dilution of a pound of soap in 30 to 40 gallons water, if applied well, would give a kill of 70 to 80 per cent. Laundry soaps like "Sunlight" or "Umbrella" brand are preferable to the soft soaps in that the former are cheaper, more easily procurable, and less liable to taint tea owing to local soft soaps containing either fish oil or some carbolic compound.

Lead arsenate, though less toxic than Paris Green, is a more popular stomach poison for general application against all leaf-eating insects. Its chief advantages are that it is a good indicator when sprayed on foliage and it does not scorch; when diluted with water it does not settle as quickly as Paris Green. Further, under estate conditions, it is an easier spray to prepare. In the preparation of Paris Green, as a spray, it is very essential to add a second ingredient, i.e., quicklime, to neutralize any soluble arsenic and thereby prevent scorching. Arsenate of lead has only to be mixed with the right

quantity of water and it is ready for immediate application. McDougall's Super Arsenate of Lead* was experimented with and found very effective (1 lb. in 30 gallons water) against young *Natada* on tea in a new clearing.

If Paris Green is preferred by estates, which may have the insecticide in stock, the following formula, as recommended by the Department of Agriculture, is suggested:—

Paris Green ½ oz., or 3 large level teaspoonfuls.
Quicklime 2 oz. or a handful.
Water 4 gallons or a kerosene tin full.

The spraying of lead arsenate or Paris Green is recommended for the control of nettle grubs in tea nurseries, young tea in new clearings, and on tea-seed bearers. But *not* on tea in full plucking.

APPLICATION.

For the application of sprays, either contact or stomach poisons, compressed air sprayers are recommended. These machines consist of a brass cylinder with a liquid and working capacity of 2½ to 3 gallons. The advantage of this type of sprayer is that when the container, which is first filled with liquid and given sufficient pressure to spray the liquid contents, is strapped on the back of the labourer, both his hands are free. He is therefore able to control the spraying hose with one hand and turn over the branches of the bush with the other—a very necessary action when spraying against nettle grubs.

It is estimated that a dozen compressed air sprayers are required to spray an acre of tea in a day. The cost of application, which includes cost of soap and labour, has on the average worked out at Rs. 15 per acre.

For the spraying of a new clearing (young tea) with arsenate of lead, it has been ascertained that an acre can be sprayed in three days with one machine, and the probable cost should be in the proximity of Rs. 8, i.e., cost of insecticide Rs. 5, labour Rs. 3.

DUSTING.

Dusting, or the application of an insecticide in powder form, so that it may replace spraying, is an urgent necessity on estates where water is a limiting factor.

All "dusts" experimented with so far have proved unsatisfactory. If sufficiently toxic to nettle grubs they have been found too costly for general use under estate conditions. Another drawback has been the difficulty of making the dusts adhere to the undersides of the leaves.

* Stocked by Messrs. Cargills Ltd. Price Rs. 2-00 per lb.

[For a list of all insecticides—sprays and dusts—which have been tested during the last two years, the reader is referred to the Annual Report of the Entomologist for 1930 and 1931, published in Bulletins Nos. 5 and 8, respectively, of the Tea Research Institute.]

BIOLOGICAL CONTROL.

In considering the biological control of a pest, which has been defined by Dr. Myers as† "the utilisation of one kind of organism for the limitation or destruction of another", the problem to be decided is whether an indigenous parasite should be encouraged or an exotic species introduced to bring about the required control.

In the present investigation it was decided to make a systematic survey of all local parasites of nettle grubs first. This was very essential. Without a knowledge of the parasites already in existence in the Island, it would have been extremely difficult to determine which parasite should be introduced at a later date. There was the likelihood of introducing a species of parasite which was already present. And further there was the possibility of discovering a potential parasite suitable for local distribution.

Of several Hymenopterous parasites discovered, the Braconid, *Rhogas* sp., gave considerable promise. It was observed to parasitise the larval stage of four species of nettle grubs irrespective of their age and size. Its complete life-cycle (when bred in the laboratory) lasted a fortnight and it was therefore capable of producing at least two generations during the larval periods of its hosts. Its efficiency ended here. Attempts to find an alternate host on which it could be easily propagated have not met with success so far.

Consequently, as suggested by the Entomologist [10] of the Tea Research Institute in his Report for 1930 and again in his address* to the Uva Planters' Association in February this year, it will be necessary to make a search for parasites from outside the Island, and Malaya, the Dutch East Indies, and the Celebes are all likely places which will have to be explored.

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† *The Tropical Agriculturist*, July, 1929, p. 43. . . .

* Published in *Times of Ceylon*, February, 24th, 1932.

The following is a list of indigenous parasites bred from nettle grubs:—

HYMENOPTERA

	Parasite	Host
Braconidae	*Apanteles* sp.	*Thosea cervina*
		T. recta
	Apanteles parasae Rohw.	*Parasa lepida*
	Fornicia ceylonica Wilkinson.	*Natada nararia*,
		Thosea cervina,
		T. recta
	Rhogas sp.	*Natada nararia*,
		Thosea cervina,
		T. recta, *Narosa conspersa*
		Parasa lepida
Ichneumonidae	*Goryphus variibalteatus* Cam	*Natada nararia*
	Hemiteles sp.	*Natada nararia*
Eulophidae.	*Euplectrus* sp.	*Natada nararia*
	Tetrastichus sp.	*Natada nararia*
	Trichospilus pupivora Ferrière	*Thosea cervina*
Eurytomidae	*Eurytoma parasae* Gahan	*Parasa lepida*

DIPTERA.

Tachinidae	*Eurigaster setosa* Dol.	*Parasa lepida*, *Thosea cervina*

SUMMARY OF CONTROL MEASURES.

1. Collect grubs when outbreak is "slight" or "medium" in severity. Collecting tins should be smeared with crude oil.
2. Collect cocoons and destroy same periodically during the day in the field from which they are collected.
3. If attack is severe and field is due for pruning, then prune attacked area. Prunings might be buried if grubs are very young. If grubs are half-grown then all prunings should be burnt immediately to prevent grubs making cocoons.
4. If field cannot be pruned then spray with a dilution of laundry soap and water (rate one pound soap in 30 to 40 gallons water.) A dozen compressed air sprayers should spray an acre in a day at a cost of Rs. 15.
5. When pest is found on (a) tea-seed bearers, (b) young tea in clearings, (c) tea nurseries—spray with either lead arsenate (1 lb. in 30 gallons water) or Paris Green (1 lb. in 60 gallons water).
6. Train a small gang of podians, 6 to 10 in number, to examine regularly throughout the year all fields and especially those which have had nettle grubs previously.

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THE MOISTURE CONTENT OF MADE TEA.

D. I. EVANS.

In the last number of this Journal it was stated that properly fired tea should contain 3-5 per cent of moisture and that tea should be packed containing 5-6 per cent of moisture. If tea is packed with more moisture than allowed above, it is liable to go off on storage and in transit. Such teas are usually reported on as being flat and sometimes as tainted.

The reason that teas containing a high moisture content deteriorate on keeping is that certain changes which are not yet understood can take place in a moist tea, and during packing and handling tea is liable to pick up any micro-organisms that may be on the floor or in the air of the factory. These organisms will flourish on a moist tea and produce mushiness or mouldiness in the tea.

The usual causes of high moisture content in tea are:—

(1) Improper firing of the fermented leaf.

(2) Absorption of moisture during grading and storage.

If the fermented leaf is passed through the firing machine too quickly the discharged tea will contain too much moisture and this is a common fault, especially when a light wither is taken. When the exhaust temperature is too high and a light wither is taken, case-hardening occurs and again teas with a high moisture content are discharged. When this occurs it will be generally accompanied by blistering, especially in the big bulk, and a moisture content of the order of 9-10 per cent will be found in the discharged tea.

Although tea may be discharged from the drier with the proper amount of moisture it will absorb moisture under certain conditions which are fairly well known. According to Deuss, (*De Thee*, September, 1926 pp. 96-101) an illustration of the absorptive capacity of tea for water is that cigars can be kept dry by storing them in tea in a stoppered bottle. He found that when tea was kept in a dry atmosphere, such as is obtained over quicklime, it lost moisture until the moisture content was about $\frac{1}{2}$ per cent. The greatest loss occurred during the first two days, and after twelve days the teas had deteriorated in quality. Tea should not, therefore, be dried too far. All teas stored in an atmosphere of 50% humidity lost moisture, while teas exposed to a saturated atmosphere absorbed moisture until they contained 26·5%. In an atmosphere of 70-80% humidity teas with the high moisture content of 14·8-15·8% lost moisture, while those containing 1-9% gained moisture. The conclusions drawn by Deuss and which have been previously published in the first issue of this journal by Petch were:—

(1) If the relative humidity of the air is not above 60-65% made tea should be sifted and stored within two days.

(2) If the relative humidity of the air is about 70-80% made tea should be sifted and stored within twenty-four hours.

(3) The sifting room should be as damp-proof as possible and it should be capable of being dried by drawing in warm air. It is preferable to have a humidity of 60-65%.

(4) If the humidity in the sifting room is less than 55% the tea loses moisture. It is not desirable to put tea on the market with too low a moisture content, since it is bad for quality and uneconomic.

In practice it is found that properly fired tea will pick up moisture very rapidly, even when kept overnight in boxes, graded and stored within 24 hours. This will be seen from the data supplied in the following table:

CHANGES IN MOISTURE CONTENT OF TEA DURING GRADING ETC.

		Moisture %	*Moisture* %	*Moisture* %
Dhool after firing	1.2.3	2·75	3·18	4·25
	4	2·58	3·08	4·70
	B. B.	2·55	3·25	5·08
Next morning before grading	1.2.3	4·67	5·85	6·17
	4	7·60	6·41	7·40
	B. B.	7·96	6·28	8·46

	Moisture %	*Moisture* %	*Moisture* %
B.O P. ...	6·35	6·77	5·47
B.P. ...	8·85	7·51	7·08
Flowery Pekoe ...	5·66	5·83	7·00
Pekoe ...	7·95	8·07	8·80
Fannings ...	8·08	7·34	7·66
Dust ...	7·47	6·75	7·30
Broken Mixed ...	8·70	7·65	8·25
Pickings ...	8·90	8·04	9·32
Fluff ...	13·90	9·85	11·10
Average hygrometric difference in grading room.	3°F.	3°F.	3°F.

The moisture content of the stored tea containing the teas described above at the time of packing was as follows:

	Per cent.
Surface of the B.O.P. in bins	7·86
B.O.P. from the bottom of the bins	6·30
Flowery Pekoe from the top of the bin	7·66
,, ,, ,, ,, bottom of the bin	8·92

The remarkable feature of these figures is the rapidity with which tea picks up moisture while stored for grading, and during the actual grading operation itself. There has been a certain amount of absorption during storage in the bins, but this is not very great as compared with the rapid change during the period between the discharge of the tea from the drier and the time the tea is stored in the bins. Although this may be true for well-constructed bins it is not true where the bins are not reasonably airtight and not situated in a dry and well-ventilated position. Unfortunately, bins are not always of good construction and properly placed in a factory. If they lie along an outside wall they should be watched very carefully, especially if there is a stream in the vicinity or if an earth wall runs alongside the factory. This frequently happens when the factory building runs into a bank, which prevents proper drying of the factory wall.

Since teas pick up moisture so readily once they have been discharged from the drier it is necessary to grade them as soon as is reasonably possible after firing. They should not be left lying about the drying room floor longer than is necessary to cool them after firing, but they should be stored in boxes and covered over while waiting to be picked and graded. It must be remembered that the drier fans suck in moist outside air into the factory, especially when the stove is inside the drying room, and unless care is taken this air may pass over the dry tea while it is cooling.

Another source of moisture gain is picking over, as this is very often done on the verandah of the sifting or drying room and generally in the lightest locality possible, i.e., near the windows. Such positions are often damp owing to leaks in the windows or in the corrugated roof, and although it is difficult to avoid this the writer desires to draw attention to the risk of the absorption of moisture when this is done. When the danger is realised precautions can be taken to minimise the trouble.

If the humidity of the grading room is high during the working period then all the grading operations will give the teas another chance of picking up moisture. The air in this room should therefore be kept fairly dry, i.e., 60-65% humidity, and this can be done by drawing in warm air from the drying room with a fan. This fan can also be used to exhaust the fluff from the grading room but the fan opening in the outside wall should be covered up during non-working hours to prevent the moist outside air from entering into the room. A wet and dry bulb hygrometer should therefore be kept in the grading room so that the humidity of the air can be checked.

Finally, care must be taken that the loft fans used for artificial withering do not draw cold outside air into the factory through the bins. If these fans are starved for air they will cause a suction effect in the drying room and draw through any leaks available, and in some instances moist air has been drawn over the stored tea in this way.

It may be argued that the absorption of moisture after firing may be corrected by refiring the tea before packing. This is true to a certain extent, especially where breaks are sent away every few days, but this is not always true where tea has to be kept some time before it is packed. If the tea in such factories is stored with too high a moisture content deterioration will take place in the bins, and refiring, although checking any further deterioration, is not a complete cure. It is therefore necessary to prevent teas from absorbing moisture during grading as much as possible.

A question that is frequently asked is, is final firing necessary? Some estates final fire as a regular practice, while others will not do so under any condition. The fact that actual complaints of soft teas have not been received is no proof that this deterioration may not have happened at times, especially when the teas are sold on the local market. It must be borne in mind that the teas may be right when they are bought in Colombo, but it is possible for these teas to arrive at their destination in a bad condition without picking up any further moisture. Complaints may then be made or not, but the buyer will take good care not to buy this mark again. Such an occurrence came to my notice during the past year, but in this instance the buyers were obliging enough to complain and also to return samples of the tea, which they described as "thin and going soft, although quite bright". The teas were reported on favourably at the time they were sold although they contained 9% of moisture. The returned samples had not picked up any appreciable quantity of moisture but had 9·8% moisture.

It is thus necessary to refire teas before they are packed if they contain more than 6% moisture.

It does not follow, however, that every break and every grade must be final fired before they are packed, since this is not necessary. The truth of this can be seen from the following figures which give the moisture content of tea obtained for packing at various times.

% MOISTURE.

Invoice		B.O.P.	B.P.	F.P.	Pekoe
A	...	10·47	11·05	9·25	9·89
B	...	7·65	9·30	7·90	9·86
C	...	5·50	6·88	5·82	—
D	...	4·80	5·30	4·00	—
E	..	4·60	—	4·00	—

It is obvious that every grade in Break A requires refiring, but in C only the B.P. grade needs final firing. On the other hand it is a waste of time and fuel to final fire any of the grades in D and E.

I have also noticed that in many cases final firing has not reduced the moisture content of the tea to any appreciable extent, when this was already of a low order. It is therefore necessary to know the moisture content of the tea in order to decide whether refiring is necessary or not.

The efficacy of the first firing should also be checked by determining the moisture content of the tea discharged from the drier. The determination of moisture in tea is dealt with in the following article:

A SIMPLE APPARATUS FOR THE DETERMINATION OF MOISTURE IN MADE TEA.

D. I. EVANS.

The reasons for determining the moisture content of made tea have already been discussed, and are recapitulated below:

(1) The determination of moisture in the fired tea serves as a check on the firing operations.

(2) It also shows whether the bulked tea contains too much or too little moisture, and thus shows whether final firing is necessary or not.

The determination of moisture in plant materials is not an easy process, but if a standard method is adopted then trustworthy results can be obtained, and the technique can be easily acquired.

The principle of the most common method is to dry a known weight of material at a constant temperature until it attains a constant weight. The loss in weight represents the moisture in the material, and the percentage in the original material is obtained by calculation. Absolute constancy of weight is, however, most difficult of attainment since loss of moisture is not the only result of heating plant material, and in practice it is usual to determine the drying period necessary to obtain a dry product. This period has been determined for 10 grammes of tea, and is found to be 3-4 hours at the temperature of boiling water. If this weight of tea is therefore dried in an oven kept at the temperature of boiling water for 3-4 hours the loss in weight can be taken as representing the moisture in the original sample of tea.

The equipment necessary for the determination consists of:

(1) Balance to weigh the tea.

(2) Water oven for drying the tea.

(3) Primus stove for heating the oven.

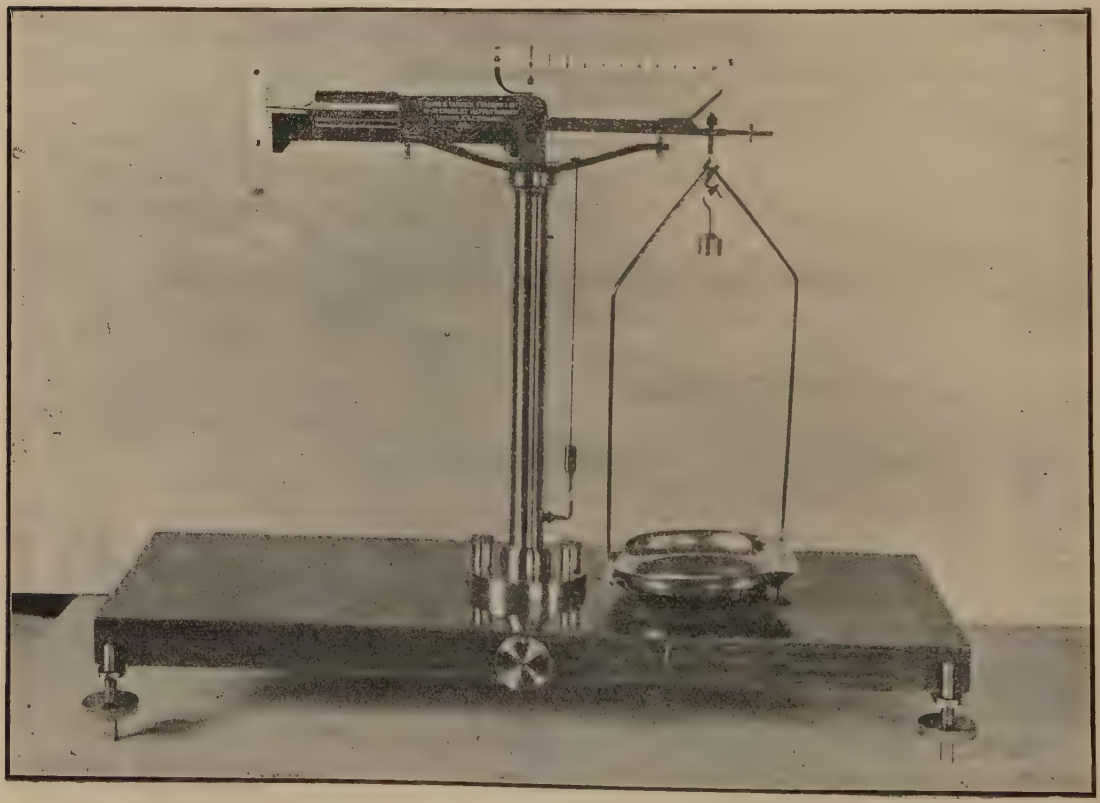
(4) Sample tins with well-fitting lids to hold the tea in the oven, and to store the sample while cooling.

(5) Instructions for the use of set.

There are several sets on the market for carrying out the operation of determining the moisture in tea, but the writer considered these too complicated and unsuitable for general use in factories. The main objection was the necessity to use fractional weights of parts of a gramme. It was considered that these weights required great care in use, and were liable to be mislaid and lost. The other drawback was the necessity to calculate the percentage moisture after the loss of weight had been determined.

In the meantime efforts were made to devise a balance which had no small weights to manipulate, and which indicated the moisture content directly. Such a balance was found to be used for the determination of moisture in butter in England and, when modified in certain ways, it was considered suitable for the determination of moisture in tea. A description of the proposed alterations and modifications was sent to the makers who carried out all the suggestions, and despatched the modified balance to the Institute for trial. When this balance was tested out at the T. R. I. Laboratories it was found to be suitable, provided a few minor alterations were carried out. A cable has been received from home that all these alterations have been attended to, and that delivery to estates could be arranged in four weeks.

The balance, a photograph of which is given below, has only one pan. This pan and the small hanging weight above it are balanced by the heavy weight on the end of the left hand beam when the small rider carried on the scale above the right hand beam is on the zero mark. When weighing the tea for the determination of moisture the hanging weight is removed and tea is poured into the pan until equilibrium is again obtained. This weight of tea will be equal to



Balance for determining Moisture in Tea.

that of the small hanging weight removed, i.e., 10 grammes. The tea on the pan is then poured into an open shallow sample tin and dried for 4 hours in an oven kept at the temperature of boiling water. At the end of this period the tin containing the tea is taken from the oven, the lid put on and the sample allowed to cool. The cooled tea is then poured back into the pan of the balance and the rider on the scale above the right hand beam moved to the right until equilibrium is again obtained. The figure on the beam under the rider when the beams are in equilibrium gives the percentage moisture in the tea directly. If a balance is obtained with the dried tea when this rider shows less than 5 the tea is too dry, but when more than 6 the tea contains too much moisture and needs final firing.

The rider beam is divided into 10 main divisions reading from 0-10% moisture. These main divisions are again sub-divided once so that readings to $\frac{1}{2}$% are quite simple. The exact position of the rider between these divisions can also be easily gauged so that readings to 0·1 per cent can be taken. It is not necessary, however, to worry whether the tea contains 7·1 or 7·2% moisture, but it is important to see that tea for packing balances when the rider is between 5 and 6 after drying. In the final modification of the balance the area 5-6 is marked on the beam in a different colour and it is suggested that when weighing the dried tea the rider should be fixed on the 5·5 mark. If the tea is lighter than this move the rider to 6·0, if heavier move to the 5·0 mark, and it will be seen immediately whether the tea is too dry or whether it contains too much moisture. An exact estimate of the moisture can then be made. If the tea is too dry the firing operation should be investigated, but if it contains too much moisture then the tea should be final fired.

The exact details of manipulation are not given in this article since full details have been given to the makers, and instructions will be sent along with the set.

The tea is dried in a water jacketed oven, which can be set on a primus stove so as to boil the water in the walls of the oven and thus keep the tea inside the oven at the temperature of boiling water. This oven must be kept supplied with water and care taken that the water in the oven just boils while the tea is drying. A cheap electric oven is being sought for those estates that have electric power available, but in the meantime the heating unit consists of a primus stove which is part of the set.

Sample tins for drying the tea have not been included in the set since these will be available on most estates, but if required they should be specially ordered.

This whole set can be obtained from Messrs. Baird & Tatlock (London) Ltd., 14-17 Cross Street, Hatton Gardens, London, E.C. 1, for £6.8.9 complete.

The apparatus for the determination of moisture in tea should be part of the equipment of every factory, and when properly used will be found to be invaluable. In conclusion, I should like to suggest that a balance case should be made on the estate to house this precision instrument so as to protect it from dust.

If a small tin of silica gel, obtainable from the makers, price 3/-, is kept with the balance in this case no trouble should be experienced with the instrument.

A SHORT NOTE ON FACTORIES AND TEA MANUFACTURE.

D. I. EVANS.

In the course of visits to various tea factories in an advisory capacity certain features have presented themselves as worthy of consideration. They will not be dealt with at length in this short note but I feel that some service will be done by focussing attention on these points.

1. CLEANLINESS IN FACTORIES.

The idea that the growth of certain organisms should be fostered in the factory is still prevalent, although it has been shown again and again that cleanliness is the first essential in teamaking. I cannot stress too strongly the necessity for maintaining every room and machine in a factory as clean as possible. Withering lofts should be cleaned regularly, while the rolling machinery and sifters should be especially watched. No leaf should be allowed to remain wedged in the battens of the rollers, the feed box, or the mesh of the roll breaker. A careful inspection of these parts of the machinery will reveal whether the cleaning has been properly carried out or not.

The drains and floor of the rolling room should be scrubbed clean, and the rolling and fermenting rooms should not be used as storerooms in any way. Where humidification is resorted to, the rolling and fermenting rooms must be opened up at the end of the day's work, so as to dry the floors and the walls, and also sweeten the room. If this is not done it is very difficult to prevent the growth of moulds and the development of taints in the teas.

Jute hessian has in the past been looked upon as the cause of factory fires but recently it has been suggested that the *tea fluff* is a more likely cause, since it enters into the lofts and settles in the cracks

of the pine boarding. If this fluff is ignited in any way it will smoulder until fanned into combustion by the fans or some other agency, and then starts a fire in the boarding. How far this is correct it is difficult to say, but the danger can be minimised by an occasional clean out of the lofts, drying room, and bulking chamber.

The outside of the factory should also be kept clean, and should not bear evidence to the excellence or otherwise of Ceylon betel, or the amount of coarse leaf thrown out of the tats.

The trolleys, sacks, or receptacles used for fermented leaf need particular attention to keep them clean and sweet.

2. FIRING MACHINES.

Care should be taken that the stoves are functioning properly, and that the tubes are in good condition, otherwise taints may be developed in the tea as a result of smoke entering the drying machine, and a cracked tube is a dangerous source of fire.

Firing machines need a very large volume of air for the fire of the stoves and considerably more for the fans. It is, therefore, absolutely essential that the fans of the drying machines can get all the fresh air they need. It is, therefore, necessary to see that this supply of air is available, and when the stove of a firing machine is fixed in the firing room this room must have plenty of openings to allow the air to enter. When the loft fans are used for withering still more air is required, and yet a common fault is trying to work a drying machine in a closed room. If the fans cannot get all the fresh air they need they will re-circulate the exhaust air, the drying room will become very hot, and bad firing will result.

In this connection the writer considers that the firing stoves should not be inside the drying room but should be separated from the room by a wall, thus preventing the possibility of re-circulating the exhaust air, the risk of ashes getting into the tea where firewood and coal are used and also minimising the risk of fire.

There is no proper provision made in Ceylon factories for the escape of the exhaust air of the driers from the factories. At the risk of causing some controversy I venture to suggest that this is a fundamental error in planning and construction that requires very careful consideration, especially when new factories are being built. At present this air has to find its way out of the factory the best way it can, through the windows or via the roof, and in many factories these conveniences are by no means sufficient. It would be far better if a properly arranged flue was arranged to remove the exhaust air directly out of the factory when not used for withering. If this is done drying rooms will not be so hot and stuffy and better firing conditions will result.

Another fault seen is when the exhaust duct of the drier is too near the floor of the loft above. This damps down the fan capacity and also results in bad firing conditions. Sometimes the exhaust air is deflected by such an arrangement towards the stove, and is re-circulated through the machine. It also heats up the loft above and gives bad withers in that loft.

3. FANS USED FOR WITHERING.

These fans must also have plenty of free air, otherwise they will draw it in through any leaks in the factory and this may have very bad effects. (See "Moisture in Made Tea".) They may also affect the proper working of the drier fans if they are starved for air, and cause endless firing trouble in this way. When fans are used to boost air through the lofts care must be taken to ensure that the exit for the air is sufficient to allow free exit, otherwise fan efficiency will be lost and stuffiness in the lofts will result.

4. DRIER THERMOMETERS.

Too often one sees the thermometers placed some distance away from the drying part of the machine instead of directly under the bottom tray of the drier. The thermometer should be placed in such a position that it will record the temperature of the air actually coming in contact with the tea, and not the air some distance away. In the writer's opinion the bulb of the drier thermometer should be placed in the middle centre just below the bottom tray. This can be easily arranged in the case of a mercury in steel thermometer by fixing a bracket to the side of the drier or else by using a special thermometer bulb. Now that proper attention is being given to exhaust temperatures it is advisable to have either a second thermometer for this purpose or else to fix double recording thermometers. It is not quite clear as yet, however, where this thermometer should be fixed, as there are two possibilities. It may be fixed above the leaf on the top tray where it should record 115-125°F, or else it may be fixed above the second tray where it should record 135-145°F. It is easily got at in the top tray but it is subjected to large variations in temperature, especially in machines of the tilting tray type when the first tray is tilted on to the next, and the top tray runs empty while it is being filled. The bulb of the thermometer then meets a hot current of air and records high temperatures. When the top tray is filled with leaf the temperature drops but the usual recording thermometer is not sensitive enough to record the lowest temperature resulting from the cooling effect of the fresh leaf. The tendency is, therefore, to show a higher temperature range than is really the case. A thermometer placed above the second tray is not liable to such large variations and should therefore give a more accurate record of the temperature conditions meeting the freshly-fed leaf.

In endless chain machines, on the other hand, the thermometer should record a steady temperature if placed a few inches above the leaf but just short of the end of the first tray, i.e., before it tilts over to the next tray.

One enterprising firm at least supplies their machines with mercury in steel dial thermometers, and these instruments are very good, but I still do not understand why the instruments are not fixed in such a way that the firing cooly can see his temperature conditions without moving from the feeding platform. There is no reason why these thermometers should not be fitted with a length of tube connection so that the dial is placed in a prominent position near to, and immediately in front of, the feeding cooly. Such thermometers are easily obtainable and should replace the present stem thermometers which are often placed in positions where it is almost impossible to read them.

5. AUTOMATIC FEEDERS.

It is a pity that the depth of the spreading is not controllable by means of a gauge which records the thickness of spreading. It is necessary to vary the thickness of spreading for the different dhools and a gauge on the spreader adjustment would simplify the spreading considerably. Perhaps the makers will pay attention to the development of such a control.

6. DRIER FALLS.

A certain amount of tea falls through the machine and over the end of the trays during the passage of the leaf through the drier. This "fall tea" sometimes appears in the discharged tea as undried pieces of tea, but fortunately this fall is not very great and generally the moist pieces complete their drying in the hot heap of discharged tea. This fall may be considerable while the first trays are passing through the machine and is then discharged before the rest of the tea passes through the machine. It is advisable to return this fall for further drying.

The other drier fall collects on the floor inside the machine, and remains there for varying periods. This fall tea should be removed as often as is practicable, otherwise it will be overfired and a big proportion of the tea will be spoilt. The quantity of this fall tea varies considerably from machine to machine and may be more than 20% of the tea fired. It becomes overfired as a result of being exposed in a dry condition to the hot air entering the machine, and the manufacturers of tea driers should make some effort to reduce this fall tea if it cannot be completely eliminated.

7. STORAGE OF TEA AFTER FIRING.

It is not practicable everywhere to pick over the leaf and sort the tea on the day of manufacture, and even if this is done the tea fired in the afternoon must be carried over to the next day. A good idea I have seen is to have special airtight bins made purposely for the storage of the ungraded tea overnight. The importance of properly constructed boxes at least for this purpose will be fully realised on reading the article on moisture in tea.

8. FACTORY FLOORS.

These should be kept in a good state of repair otherwise grit and sand will find their way into the tea. Badly kept floors are also very difficult to keep clean.

THE GERMINATION OF TEA SEED

F. R. TUBBS.

The seed of tea consists of 2 cotyledons enclosed by a thin papery integument and a thick woody shell. In ripe seeds an air space is usually found to occur between the cotyledons and the shell, which increases upon exposure to drying influences and decreases when the seed absorbs water. In a series of samples of normal seed as obtained for propagation, the mean volumes of cotyledons, air-space, and seed shell were found to be 1·664 cc., 0·211 cc. and 0·466 cc, respectively. Data have been collected on the rôle played by these portions of the seed during germination.

The air space within the seed appears to serve no function, its size depending upon the moisture content of the cotyledons which expand and contract markedly with fluctations in the amount of water they contain.

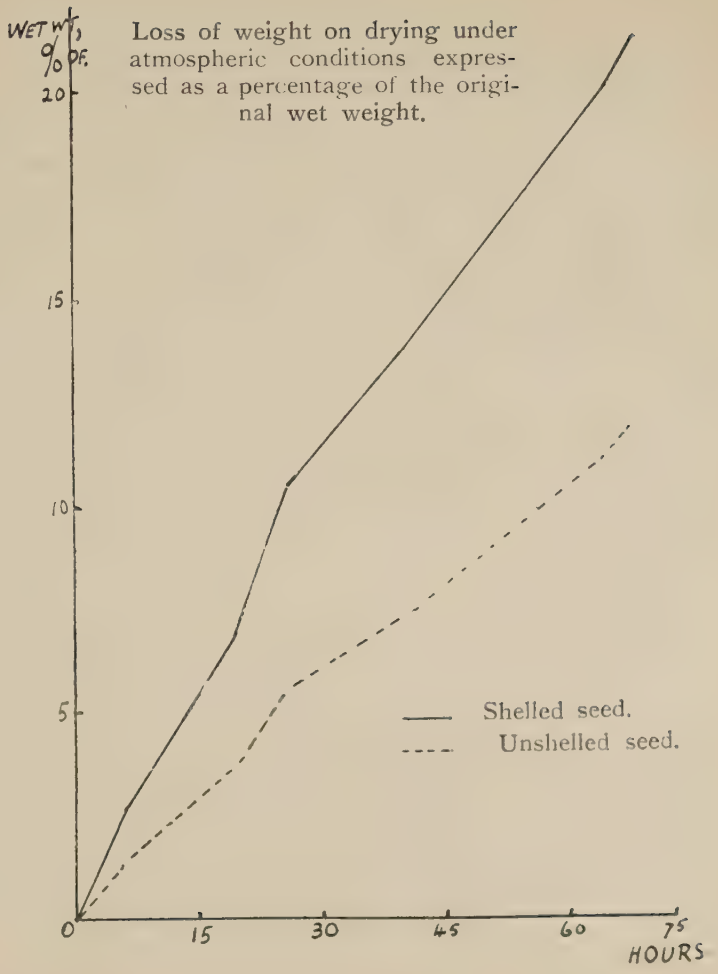
In Figure 1 is shown the effect of the presence of the seed coat upon the absorption of water from wet sand. The "shelled" seed, from which the seed coat had been entirely removed, absorbed water much more rapidly than did the unshelled seed, which was still enclosed in an uncracked shell. As would be expected, a similar effect is observable when the seed is allowed to dry out, the loss of water from "shelled" seed being more rapid than from unshelled seed (Fig. 2). In both cases the presence of the seed shell slows down the rate of absorption or loss.

The effect of this barrier to free liquid and gaseous exchange between the soil and the living parts of the seed, as shown by the relative rates of growth of "shelled" and "unshelled" seed, has been

Fig. 1

Weight of water absorbed expressed as a percentage of the original wet weight.

Fig. 2



Loss of weight on drying under atmospheric conditions expressed as a percentage of the original wet weight.

examined. The "unshelled" seeds were weighed and sown at a depth of 1 inch in soil. The "shelled" seeds were cracked with a hammer and the cotyledons and seed shell separated and weighed, and sown similarly. The two lots of seeds, each 250 in number, were sown in parallel lines, randomised in pairs, to reduce errors due to differences in soil fertility.

Samples of each group were taken monthly, the plant organs being weighed individually in fresh and dry condition. It was subsequently found necessary to discard the records of plants suffering from insect injury.

The first visible sign of germination in the unshelled seed was the cracking of the seed shell; 52, 72, and 100 per cent being cracked after 1, 2, and 3 months, respectively. The cracking of the shell was associated with the absorption of water. This occurred at a lower rate than in the case of shelled seed. The water content of the cotyledons expressed as a percentage of the dry weight are given in Table I.

TABLE I.

Water content of seed leaves expressed as a percentage of the dry weight

Months	0	1	2	3	4
"Unshelled"	94·3	103·7	127·4	214·0	322·2%
"Shelled"	94·3	133·3	158·2	266·7	358·9%

The growth of the embryo is accompanied by a steady drain upon the reserves contained in the cotyledons, which decrease in weight and finally become morbid—a change that is accompanied by a large increase in the water content. About this time—five months in the case of "shelled" seed and six months in that of "unshelled" seed—abscission of the cotyledons commences. This appears to begin when about 60% of the original dry weight of the cotyledons has been lost.

TABLE II.

Mean loss in weight of cotyledons and the percentage cut off.

Loss in Grammes.

Months	Shelled	Loss in grms. unshelled	Months	Percentage shelled	Cut off unshelled
1	·049	·019	5	17·9	0·0
2	·084	·041	6	60·0	27·0
3	·333	·184	7	69·1	31·3
4	·560	·281	8	65·9	41·6
5	—	·555	—	—	—

As would be expected, the more rapid translocation of food materials from the cotyledons to the growing plant observed in the shelled seed is accompanied by more rapid growth of the seedling. (Fig. 3). This difference in growth rate is not continued indefinitely, however, a slowing off in the growth of the "shelled" seedlings occurring about the time of abscission of the cotyledons. This is followed by a new period of rapid growth dependent upon the supply of energy from the green leaves alone. The "unshelled" seedlings terminate the first growth period later than the "shelled" seedlings. These differences in amount and rate of growth are also discernible in the growth of the leaves, roots and stems (Fig. 4).

The seedling obtains its supplies of energy and salts at first from the cotyledons, but later from external media. The food reserves of the tea seed are in the form of starch and oil. During germination, the amount of either soluble material in the cotyledons (oil, fat, etc.) falls, owing to its use by the growing plant, a loss of 65% of the oil occurring in three months in the unshelled seed, compared to 86% in the case of seeds from which the shell had been removed. At the same time 19% and 28% of the total nitrogen originally present was lost by the cotyledons of the unshelled and shelled seed respectively. The speedier removal of stored food from the cotyledons of the shelled seed is probably to be attributed to the earlier and more copious supply of water and oxygen to the cotyledons of the germinating seed.

The data show that an increased rate of germination and growth result from the removal of the seed shell. The complete removal of the shell requires considerable care, and destroys the mechanical protection to the seed offered by it. Gadd's* suggestion of *cracking* the seed is supported by the results of the experiment described. Such a method gives easy access of water and oxygen to the embryo and results in a higher percentage of germination in a shorter time.

* Gadd, C. H. *Tea Research Institute Bulletin* No. 3, 1928, p. 16.

Fig. 3

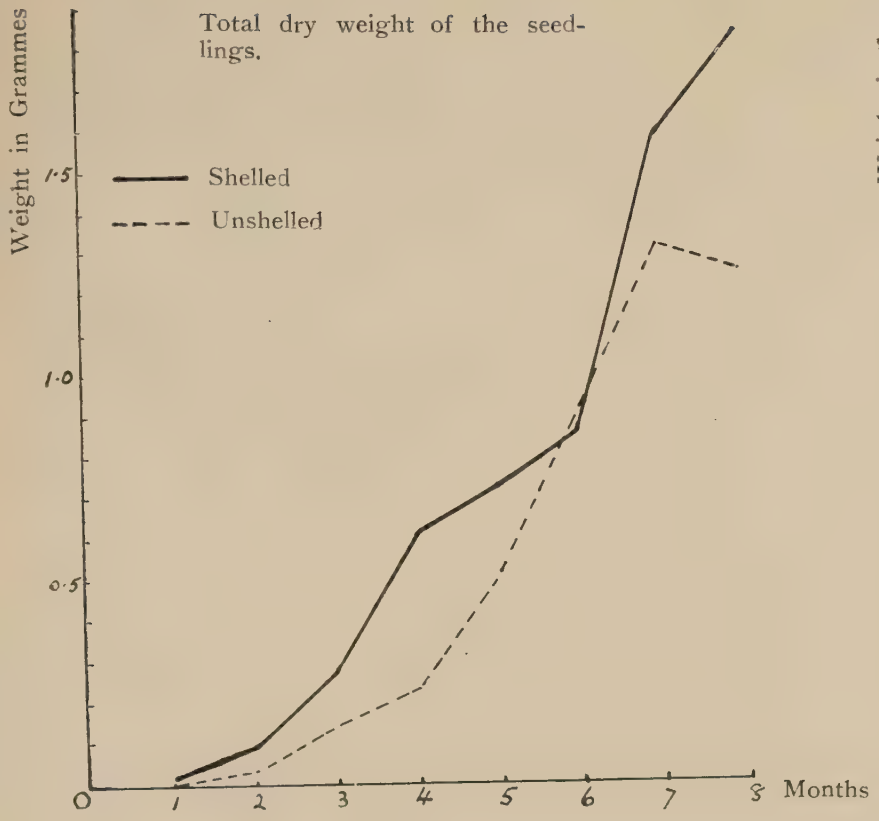
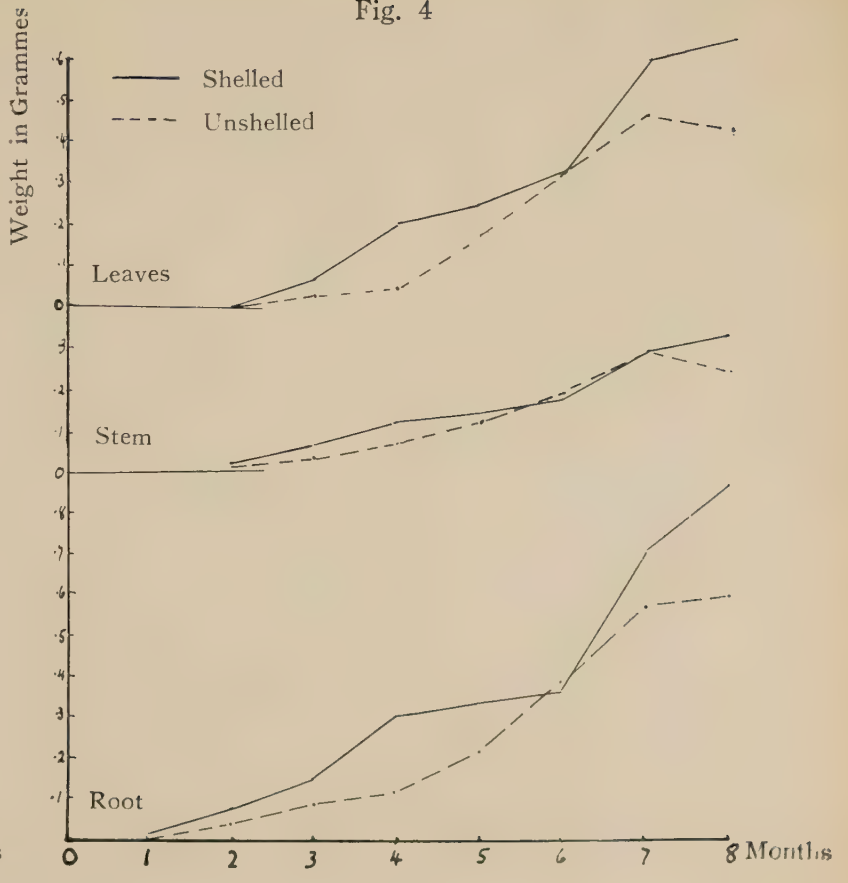

Total dry weight of the seedlings.
Weight in Grammes
Shelled
Unshelled
1·5
1·0
0·5
0
1
2
3
4
5
6
7
8
Months

Fig. 4


Weight in Grammes
Shelled
Unshelled
Leaves
Stem
Root
0
1
2
3
4
5
6
7
8
Months

A SHORT NOTE ON SUCTION DRYERS

D. I. EVANS.

Many estates I have visited complain of failure to get the good results they expected on improving factory conditions. Near-by estates with similar or even indifferently equipped factories have been doing well for some reason or other; and no variation in manufacture seems to improve the quality of the tea, which often gives thin liquors, dull infusions and not much flavour. Most of these factories have suction dryers while the adjacent factories are fitted with pressure dryers.

Observations made on such dryers have given rather peculiar results, which are given for the benefit of readers, in spite of the fact that the records are not yet sufficient to be conclusive. The outstanding observation is that the dryer thermometers may show a temperature of 190-200°F and give one the impression that the firing is satisfactory, but when the temperature is taken below the bottom tray in the middle of the machine the temperature may be very much higher. In one case this temperature was 236°F when the dryer thermometers showed 200°F, and in another instance the temperature under the bottom tray was 230°F when the dryer thermometer showed 192°F. The exhaust temperature was 120-130°F and therefore satisfactory and the dryer thermometers when checked were correct. The teas turned out were not satisfactory.

The explanation of this discrepancy appears to be that in suction dryers the greatest pressure is in the middle, and that the fan tends to concentrate the air in the middle of the machine. This means that the heat supply is greatest to the middle of the machine and not to the sides. On the other hand the greatest loss of heat is at the sides so that the air has to be heated higher than necessary in order to produce the temperature required at the sides of the machine. The temperature recorded by thermometers on the side of a machine thus shows the temperature of the coolest air and not of the general conditions. The greatest discrepancy in temperature occurs when a current of cold air runs past the side of the dryer, especially when the withering fans are taking air from the drying room, but this may be remedied to a certain extent by partitioning the dryer stove from the drying room thus sheltering the drying machine from draught, and arranging for the cold air supply to the loft fans to be taken from some other source, or over the top of the machine. A rush of cold air past the sides of the dryers must be avoided, and thermometers should be placed so that they record the temperature under the middle centre of the bottom tray.

All leaks in suction dryers must be attended to, otherwise cold air will be sucked into the machine.

REVIEW OF THE WORK OF THE SCIENTIFIC STAFF—JANUARY-MARCH.

Forty-two consignments of diseased specimens were received for examination in the Mycological Division during the period under review, of which thirty-six related to tea. In seventeen cases the cause of the trouble was physiological, while ten were root diseases.

A further case of *Rhizoctonia solani* causing a leaf disease of tea has been under observation. The fungus develops in the centre of the bush first where atmospheric conditions are most suitable and thence spreads outwards. The attacked leaves ultimately fall off though some remain suspended by a thread or become webbed to other leaves still adherent to the stem. These fine threads, somewhat resembling a spider web, are the parasitic fungus.

Witches' Broom became prevalent in the Kandapola district after somewhat abnormal weather at the end of last year. With an improvement in the climatic conditions many of the bushes made a marked recovery and the Witches' Broom symptom is disappearing.

The work on *Bacillus radicicola* has been continued by the Mycologist. The technique used in carrying out cross-inoculation has proved unsuccessful and experiments have been started to improve this.

Investigations have been started to determine the part micro-organisms play in the manufacture of tea.

In the Entomological Division seventeen pests from various districts were recorded during the period. Included in these was some kind of spider reported about the same time from Uda-Pussellawa, Gampola, Namunukula and Bandarawela as being in large numbers, webbing up the tea bushes. The nettle grub, *Thosea cervina*, was found on an estate in Bogawantalawa in March.

Tortrix appeared, as usual, with the new year. Eggs were freely laid for about three weeks, and the number of egg masses later declined rapidly. A sharp attack of the caterpillars followed, but by the end of March the position had considerably improved.

Several thousand egg parasites were received from England towards the end of January, of which about eighteen hundred survived. Since that time, they have been passed through several generations. The moth breeding in the breeding room had to be stopped on account of *Tribolium* beetles, which flourished to a much larger extent in the meal than the grain moths. It is a very difficult pest to get rid of and several fumigations were found necessary to

kill it off. However, sufficient eggs were obtained to carry on breeding both moths and parasites, of which small liberations were made on the estate.

Aphis was reported twice. These small bugs are often found on tea coming on from pruning, sometimes quite thickly on the young shoots, but they do not do sufficient damage to warrant any special measures being taken. They sometimes become heavily parasitised, and the larvae of Syrphid flies and lady bird beetles may be found feeding freely on them.

Nettle Grub was very mild during the quarter, making experimental work somewhat difficult. However, a few proprietary sprays were tested on a small scale. Parasites have been very scarce during the quarter. This is not unusual; if they become at all prevalent, it is usually during the S. W. Monsoon period. Efforts are being made to obtain two fly parasites for *Thosea*, through the Farnham Royal Laboratory in England. Bad attacks of Nettle Grub in the past have usually been reported when at its maximum, or thereabouts, and at this stage little can be done to cope with it. Recent field work has shown that incipient attacks may be discovered in the very early, even egg, stage, by having a few podians trained to look for these things. Such a gang, if kept continuously combing the estate, should prove useful in countering the development of an attack by giving early warning. The monthly card reports of the presence or absence of Nettle Grub received during the quarter amount to only about 50% of those issued.

The Plant Physiologist has continued in charge of all Field Experiments. The second portion of the St. Coombs pruning experiment has been initiated and arrangements completed for the similar experiments at Peradeniya and Galatura. Acknowledgments are due to the Department of Agriculture and to Messrs. James Finlay & Co., Ltd., for their co-operation.

In connection with work on different tea races further supplies of seed have been received from Java and elsewhere and some 59 races will be available for the test. A study of the effect of jât on withering has also been commenced.

Work on defoliation is continuing in this section and the influence of defoliation on nitrogen uptake is being studied. Routine plucking of the manurial experiments continues and indications of variations between the different treatments are becoming apparent. Leaf from the no-nitrogen and double-nitrogen plots is being manufactured on the small scale plant. Reports from brokers, however, reveal no consistent differences in quality or valuation between these samples.

The plots suffered somewhat from Tortrix attacks at the beginning of the year but these have now abated.

Multiplication plots for various types of cover crops have given satisfactory growth and ten varieties will shortly be put down in quarter-acre blocks in the new clearing and under old tea.

The time of the Biochemist has been largely taken up with an examination of firing conditions. Six hundred and sixty three tea samples were received from estates for moisture determinations in connection with the above work.

By means of a questionnaire sent to estates forwarding such samples a considerable mass of information has now been accumulated regarding firing conditions. The outstanding feature of these returns is the very large variation in firing conditions from estate to estate. Thus the output for the same type of machine may vary on different estates from 70 to 130 pounds per hour.

In order that estates may be in a position to carry out their own moisture determinations and so check their firing conditions, arrangements have now been made with Messrs. Baird & Tatlock, Ltd., London, for the supply of a cheap and efficient set of apparatus for this purpose. Details will be found elsewhere in this issue.

An important series of experiments on withering is now in hand, the first point for determination being the effect of the period of withering on the made tea. Invaluable assistance in this connection is being rendered by Colombo and London brokers who are making regular valuations of the experimental samples. A definite system of marking for colour, strength, pungency, quality, etc., has been evolved and it is hoped results of considerable practical value will be obtained.

Mr. De Silva has been in charge of the Agricultural Laboratory during Mr. Eden's absence on home leave. Work is continuing on the examination of the clay fractions of representative soils, this should lead to a proper classification of Ceylon tea soils.

Regular analyses are also been carried out on soil samples from the plots in the 1931 clearing, in half of which the patna was burnt before planting, in order that the losses of organic matter and nitrogen due to the differential treatment may be studied.

ROLAND V. NORRIS.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON.

A Meeting of the Board of the Tea Research Institute of Ceylon was held at St. Coombs Estate, Talawakelle, on Tuesday, the 29th March, 1932, at 2-15 p.m.

Present.—Mr. R. G. Coombe (Chairman), the Hon'ble the Financial Secretary, the Director of Agriculture, Messrs. A. G. Baynham, G. K. Stewart, D. H. Kotalawala, M.S.C., J. A. D. Finch Noyes, John Horsfall, C. C. du Pré Moore, A. W. L. Turner, (Secretary), and by invitation Mr. J. W. Ferguson, Dr. Roland V. Norris, Mr. C. Huntley-Wilkinson, Mr. J. A. Rogers, Dr. C. H. Gadd, Dr. D. I. Evans, Mr. C. B. R. King and Mr. F. R. Tubbs.

Absent.—Major J. W. Oldfield, O.B.E., M.C., M.S.C., Major H. Scoble Nicholson, O.B.E., and Mr. C. H. Z. Fernando.

Most of the members of the Board assembled at St. Coombs Factory at 8-30 a.m. on the same date and inspected the Institute's property.

1. Notice calling the Meeting was read.

2. Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held on the 5th February, 1932, were confirmed.

Letters regretting inability to be present at the Meeting were received from the following members:—Major J. W. Oldfield, Major H. Scoble Nicholson, and Mr. C. H. Z. Fernando.

3. MEMBERS OF THE BOARD, T. R. I.

Before proceeding with the business of the Meeting, the Chairman welcomed Mr. D. H. Kotalawala, M.S.C., on his presence at a Board Meeting for the first time. He also welcomed the members of the Senior Scientific Staff, who were present by his invitation.

He congratulated Mr. Baynham on being elected Chairman of the Planters' Association of Ceylon for the third time in succession.

He announced that the Planters' Association of Ceylon had elected Mr. C. Huntley-Wilkinson to act for him (Mr. Coombe) on the Board during his absence from Ceylon.

4. PROGRAMME OF WORK.

Arising out of the Minutes, the Chairman invited the Scientific Staff to report progress on certain points raised by Mr. Finch Noyes at the last Meeting of the Board, as follows:—

(a) *Assessment of the value of Artificial Withering and Comparison with Natural Withering.*—Mr. Finch Noyes asked if it was possible to say how far quality in tea was affected by the length of time of withering.

Dr. Evans said that he had commenced investigations on this subject prior to the last Meeting. At present he had insufficient data to make a definite statement, but the whole question of withering was now receiving intensive study.

Mr. Stewart asked whether any opinion could be given as to the relative merits of different withering systems. Dr. Evans said that some data had already been collected and every opportunity would be taken to compare the working of "reversible" and "alternating" withering systems.

If members at any time wished for information on any specific points he would be glad to give them any figures available.

Mr. Horsfall suggested that before pronouncing an opinion on such systems it might be as well to ascertain whether the installation tested had been put in in accordance with the specification of the firm concerned and was working to their satisfaction.

(b) *The utility or otherwise of exhaust fans in rolling rooms with particular reference to any possible loss of flavour.*—Dr. Evans said that at present he had nothing to report.

5. FINANCE.

Statement of Accounts for the month ending February 29th, 1932.—The Chairman said that a copy of these Accounts had been sent to each member of the Board on the 23rd February, 1932, and drew attention to the fact that two instalments (1/9th) i.e., for February and March, of the repayment of the loan from Government had been placed on fixed deposit, and 2/9th would be placed in April, and 1/9th per mensem thereafter.

It was decided that the appropriate proportion of furlough and passage money should also be placed on fixed deposit monthly.

There being no further comments the Accounts were passed.

6. ST. COOMBS ESTATE.

Bungalows.—Satisfactory progress on the two new bungalows was reported.

7. JUNIOR STAFF, T. R. I.

The Director stated that in accordance with the Board's instructions, he had advertised for two Assistants in the Biochemical Division *vice* Mr. B. N. Sastri resigned. He had received some 170 applications, and had finally selected two ex-University College men,

The Board approved of the Director's selections.

Mr. E. L. Keegal as from the 15th March, 1932, and Mr. P. R. Perera as from the 1st April, 1932.

8. PROVIDENT FUND OF JUNIOR STAFF.

The Director announced that the Junior Staff had elected Mr. E. N. Perera as a trustee to fill the vacancy caused by the resignation of Mr. B. N. Sastri.

9. WITCHES' BROOM DISEASE.

This subject was brought forward by Mr. C. C. du Pré Moore, who wished to know if the Institute was making investigations in this connection.

Dr. Gadd replied that the disease was first noticed in Ceylon in 1920 in the Bandarawela District and from then until recently it had been investigated from a mycological point of view only. The disease was known in Nyasaland and India and in some cases appeared to be curable with extra applications of manure, but this was by no means true in all cases. A later suggestion was that it was a virus disease but this had not yet been proved. Work on the subject would continue in collaboration with other sections.

10. REPORTS ON MANUFACTURE.

Speaking to this item, a member suggested that it was unwise to publish the Institute's discoveries.

The Chairman pointed out that the Empire Marketing Board's grants were made on condition that all discoveries were to be at the disposal of the Empire.

The Director said that there were three main reasons against the suggestion:—

(a) The condition on which the Empire Marketing Board granted assistance.

(b) If the Institute did not pass on information it would soon be found that they could not get information from other institutes.

(c) The information passed to estates in Ceylon was bound to be transmitted to South India because many Colombo Agents had estates in both countries.

The question was dropped.

11. CONFERENCES OF THE T. R. I.

Third Conference.—It was decided that the Third Conference should be held at St. Coombs Estate, Talawakelle, on January 26th and 27th, 1933.

12. MINUTES OF EXPERIMENTAL & ESTATE SUB-COMMITTEE MEETING OF 4-2-32

(a) *Factory Data.*—Dr. Evans announced that he had procured a balance from Messrs. Baird, Tatlock & Company, made to his specification, which would enable superintendents to ascertain the water content of their manufactured teas.

It was decided that details of the cost and working of these instruments should be passed on to the Chairman of the Ceylon Estates Proprietary Association and the Chairman of the Planters' Association of Ceylon with the request that the Chairman of the C. E. P. A. should inform the members of his Association who in turn would inform their tea estate superintendents, while the P. A. should inform District Planters' Associations.

(b) *Tuition.*—The Director stated that he had consulted his staff on this matter and that it was felt that due to the want of accommodation the time was not ripe for instituting classes of instruction for senior and subordinate staffs on estates. The Director further pointed out that if accommodation were available they could hold classes for 10 or 12 individuals when the benefit resulting would be commensurate with the time and trouble taken. Instruction to smaller numbers hardly seemed to justify the interruption of the work of the Scientific Staff.

(c) *Cover Crops.*—Mr. Tubbs stated that $2\frac{1}{2}$ acres in the new clearing and $2\frac{1}{2}$ acres in old tea had been allotted to these experiments and that these areas would be sub-divided into quarter-acre plots. Four species of cover crops had already been planted for seed production and in all 10 species would be tried and the results made known in due course.

(d) *Pruning Experiments.*—Mr. Tubbs announced that further pruning experiments would commence on the following dates:—

Galatura	——April 20th.
Peradeniya	——April 27th.
St. Coombs	——May 4th.

(e) *Jât.*—Mr. Horsfall suggested that in addition to the present jâts of tea seed which were under observation a few pounds of the original mother type of dark and light leaf variety should be obtained if possible.

The Director of Agriculture said that he did not anticipate insurmountable difficulty in obtaining permission to import a few pounds only. He suggested that it should be ascertained where the original tea seed came from.

It was decided that the matter should be referred to Tocklai.

13. SMALL-HOLDERS.

The Director said that he had gone further into this question and again thanked the Director of Agriculture for the details he had supplied. He proposed to send Dr. Gadd to one or two districts (to be decided on later) to study conditions of the small-holders with the assistance of the District Officers of the Department of Agriculture.

The Director of Agriculture undertook to assist in any way he could.

Mr. Kotalawala referred to figures of small-holders in the Gampola and Nawalapitiya Districts which were published in the Minutes of the Meeting of the Board held on the 5th February, 1932.

After full discussion it was decided to await Dr. Gadd's report which should be referred to the Small-holders Sub-Committee to which Mr. D. H. Kotalawala, M.S.C., and Mr. C. H. Z. Fernando were duly elected *vice* the Hon'ble Mr. T. B. Panabokke, M.S.C., and the Hon'ble Mr. D. S. Senanayake, M.S.C., Dr. Gadd was also nominated as a member of this Committee.

14. TORTRIX

At the Chairman's request Mr. Redman King outlined the progress made in connection with parasite control of Tortrix.

15. CHAIRMANSHIP.

Mr. C. C. du Pré Moore proposed that Mr. G. K. Stewart be appointed Chairman during Mr. Coombe's absence on leave.

Mr. John Horsfall seconded the proposal.—Carried unanimously.

Mr. Baynham, speaking on behalf of the Board, thanked Mr. Coombe for the services he had rendered to the Tea Industry during the long period he had occupied the Chair of the Institute.

Mr. Baynham's remarks were received with applause and Mr. Coombe having thanked him, the Meeting terminated.

A. W. L. TURNER,
Secretary.

NOTICES.

The Institute's Laboratories are situated at St. Coombs, Talawakelle, and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station c/o Messrs. Hemachandra & Co., Forwarding Agents.

Visitors' Day.—The first Wednesday in each month has been set aside as Visitors' Day at St. Coombs Estate, when it is hoped anyone interested will visit the Station.

Visitors at other times are welcome but the Staff may not be free to show them round. Such visitors, on arrival at the Factory, are requested to ask for the Teamaker.

St. Coombs Estate is reached by taking the turn-off opposite culvert marked 28/10 on the Nanu Oya-Talawakelle main road. A signpost has been erected at the turn-off.

Publications.—Applications for the Institute's Publications should be directed to the Secretary, at Victoria Commemoration Buildings, Kandy, and *not to the Director's Office.*

ROLAND V. NORRIS,
Director.

EDITORIAL.

THE T. R. I. CONFERENCE.

The Third Conference of the Tea Research Institute of Ceylon will be held at St. Coombs on Friday and Saturday, January 27th and 28th, 1933. On the first day papers will be given by members of the Staff and discussions organised on matters of general interest; while on the second day facilities will be arranged for visitors to see round the laboratories and estate and to discuss their particular problems with the Staff.

Full details will be announced in the next number of *The Tea Quarterly*.

SMALL-HOLDINGS.

For some time the Board of the Institute has had under consideration measures for affording more direct assistance to small-holders in tea, and in March this year Dr. Gadd was deputed to make a study of this problem. At the same time a Sub-Committee consisting of Mr. D. H. Kotalawala, M.S.C., Mr. C. H. Z. Fernando, the Director of Agriculture, the Director, Tea Research Institute, Dr. C. H. Gadd and the Secretary, Tea Research Institute was appointed to make recommendations in regard to the immediate steps to be taken.

Statistics which have been collected indicate that small-holdings in tea amount in all probability to an area of about 31,500 acres, the number of individual holdings being about 7,350, of which some 60 per cent are situated in the Central Province. Of these holdings, about 40 per cent do not exceed one acre in extent, while only about 16 per cent exceed five acres. The difficulty of dealing with such small units will be obvious, the problem becoming largely one of economics. A review by Dr. Gadd of the general position will be found in the present number and comments from planters in touch with small-holders will be welcomed. The Small-Holdings Sub-Committee met on the 27th July and after a very full discussion made a series of recommendations for immediate work which will be found in detail on page 87.

These recommendations were approved in principle by the Board at a meeting held on 28th July and have already been implemented by the appointment of a Small-Holdings Officer by the Tea Research Institute. This Officer will take up his duties from October 1st, and will in the first place work in the Uda-Palata area. He will at once proceed to make a survey of the area selected in order to get in touch with the small-holders and to select holdings which can be worked

under his advice and serve as demonstration centres. Subsequently a small area will probably be leased and worked directly by the Small-Holdings Officer as a demonstration plot. In view of the economic difficulties which beset the small-holder, the question as to how far assistance can be given through the agency of Co-operative Societies will also be examined.

When experience has been gained of work in this area it is hoped, as funds permit, to extend these activities to other districts.

NETTLE GRUB.

It does not appear to be realised that superintendents of estates in the Uva Province are now required to report all attacks of Nettle Grub to the Department of Agriculture. It is hoped planters will co-operate by making these returns as complete as possible.

TEA CIDER.

Any suggestions for increasing the consumption of tea are of general interest and attention is, therefore, called to a circular issued by the Tea Expert Bureau, Java, describing a fermented beverage prepared from tea which seems to be highly popular in the Dutch East Indies. Part of the circular will be found reprinted in this issue on page 126.

The Tea Cider is prepared by inoculating a tea infusion containing about 10 per cent of added sugar with a small amount of "tea fungus". The latter has been known for a good many years, having been introduced into Germany from Russia about 1911. Its origin is unknown but was probably some eastern country. The "fungus" is actually a mixture of a kind of yeast and a bacterium and develops rapidly in a tea infusion prepared as above and kept at a suitable temperature—25 to 30°C. If the fermentation is stopped at the proper time the resulting liquid forms a pleasant beverage closely resembling cider. If, on the other hand, the fermentation is prolonged, vinegar is produced and it has also been used for this purpose in Java. In addition to its properties as a beverage, Tea Cider is claimed to possess certain medicinal qualities, having been found useful in cases of rheumatism and arterio-sclerosis.

The preparation evidently presents no difficulties and has been widely taken up in Java by the villagers.

Specimens of the culture have recently been obtained from Java by the Institute and the methods of employing this are under examination.

MOISTURE IN TEA.

With reference to the standard set for moisture determinations in tea recommended by the Institute and described in the last issue

of *The Tea Quarterly*, attention has been called to the objections raised by Insurance Companies to the use of primus stoves or similar pressure heaters in factories. Any convenient heater can, of course be used for heating the oven instead of a primus stove and where electric current is available electric heaters form a convenient substitute.

INSECTIVOROUS BIRDS.

In the conditions prevailing on most tea estates in Ceylon where trees of suitable types are scarce, but little bird life is evident. This is unfortunate in view of the useful part which is played by certain birds in keeping down insect pests. The possibilities of this form of control are evidenced by reports of observations made in other countries, notably Germany, where birds have been found most effective in keeping down certain forms of Tortrix. The Institute is anxious to obtain further information in regard to the activities of insectivorous birds in Ceylon and would welcome details of any observations of this kind which may have been made by planters.

MANURING.

We are glad to publish in the present issue an article by a contributor dealing with the question of inorganic and organic artificial manures. The subject is of the greatest importance at the present time in view of the urgent call for economy in manuring programmes. The question as to how far expensive organic manures can be replaced by cheaper inorganic is one which deserves the fullest consideration in the present difficult times. Mr. Thomson puts forward a very ingenious argument for the continued use of organics. It is not, perhaps, a question to which an answer of general application can safely be made at the present moment since so much depends on the previous manurial history of any particular estate and in particular on the amount of green manuring which the soil has received, and in the present state of our knowledge it would appear advisable to insist that where inorganics are to be exclusively used green manuring should be as intensive as possible.

Many points remain to be cleared up in regard to organic manures. There is considerable evidence that the action of such manures under tropical conditions is not so gradual as is frequently supposed and experiments by Joachim which were reported at the Agricultural Conference in 1928 indicated that in soils well stocked with organic matter there was no significant difference in leaching losses between blood meal and sulphate of ammonia.

The manurial experiment at St. Coombs has so far shown little or no difference in yield between plots treated with sulphate of ammonia, cyanamide or blood meal. Recent trials at Rothamsted with other crops have also failed to indicate any superior efficiency in organic artificials.

There appears to be a somewhat general impression that the wider use of inorganics might lead to a loss in quality. It is, however, probably overlooked that whatever the nature of the nitrogenous manure applied, the form in which the nitrogen is actually taken up by the bush is the same in each case. There would, therefore, appear to be little reason why the nature of the manure should influence quality in any way, provided such manures are applied in reasonable quantities and at appropriate times, care being taken to avoid undue forcing of flush. In other words it would seem that the quantity of nitrogenous manure applied, rather than its nature, is the point to be considered so far as the quality of the resulting tea is concerned.

Experiments are in preparation at St. Coombs which it is hoped will throw some light on the considerations outlined above. It will, however, probably be agreed that even as things stand now there is much scope for the simplification of the manure mixtures at present in common use in Ceylon estates and we have little doubt that, provided green manuring on a sufficiently extensive scale is carried cut considerable economies could be effected in many manurial programmes.

TEA IN RUSSIA.

We reprint from the Quarterly Journal of the Indian Tea Association an exceedingly interesting article by Dr. H. H. Mann on tea growing in Georgia. From this review it would appear unlikely that Russia will ever be independent of other countries for its supplies of tea and the present developments may in fact be regarded as helpful, keeping alive the demand for tea which has been so severely restricted by recent economic conditions.

ROLAND V. NORRIS.

FITTING ARTIFICIAL MANURING TO GREEN MANURE SUPPLIES.

W. R. THOMSON, B. Sc. (Agric.)

The importance of Green Manuring has been impressed on the planting community of Ceylon by many writers in recent years but no discussion of the modifications which might reasonably be made in the supply of artificial manure when accompanied by green manure, has been noticed.

The value of green manure as a supply of nitrogen was discussed very fully by Eden recently (*Tea Quarterly*, Feb., 1932), in which he explained that the new nitrogen supplied was possibly an extremely small amount and that the practical effects of green manuring bore this out, in that results were certainly not as striking as the earlier writings on the subject would lead the practical man to expect.

Eden (*loc. cit.*) also makes the remark that there is much to be said for the practice of forking in artificials along with green manure. It is with the further elaboration of the results arising from this practice that the writer is concerned.

The amount of green manure available for burying at any one operation is very variable but for the purposes of the following estimations some figure has to be used and a good average weight per acre after deducting the woody portions which are too coarse for burying may be taken as 4,500 lbs. This figure will vary from estate to estate and from field to field, but an estimation of the amount can always be made for particular cases without much trouble.

The dry weight of this green manure will be approximately a third of its weight when freshly cut and the dry material will on an average contain about 2·5% of nitrogen and 30-35% of carbon, both figures being dependent on the proportion of woody material to leaf.

The buried green material as explained by Eden (*loc. cit.*) ultimately becomes part of the humus fraction of the soil and as this contains about 2% of nitrogen and 20% of carbon the process involves the loss of some nitrogen and more carbon. The process is bacterial and as there is a large excess of carbon the bacteria will turn elsewhere for the nitrogen necessary for the continuance of their life-cycle. It is to this "free" carbon that the value of forking in artificials along with green manure is due.

Every 100 lbs. dry weight of green manure will contain at least five pounds and possibly more carbon which will as decomposition progresses be "freed" to combine with outside nitrogen. Under the conditions of estate practice the mixture of artificials and green

manure is probably not sufficiently intimate for the process to reach theoretical efficiency and 5 lbs. of carbon per 100 lbs. of dry weight Green Manure may be taken as a reasonable figure of available carbon.

In the case under consideration 4,500 lbs. of green manure was to be buried. The dry weight of 1,500 lbs. will supply 75 lbs. of "free" carbon. This 75 lbs. of free carbon per acre is able to combine with or absorb as the bacteria break it down, 1 lb. of nitrogen for every 10 lbs. of carbon, i.e., 7·5 lbs. of nitrogen. This 7·5 lbs. of nitrogen could be supplied by 38·5 lbs. of sulphate of ammonia and this quantity would be locked up in the humus and released slowly as the humus breaks down.

The possible errors in the above calculation are, of course, very big. Beyond the fact that free carbon can be combined with nitrogen in the way described there is very little solid information to work upon. The carbon available may vary to a large extent with the quality of the green manure buried and the efficiency of the process in practice cannot be ascertained. The estimation of the various factors is as close as possible and the interaction of green manures with artificials can be calculated in no other way.

The 7·5 lbs. of nitrogen taken into the humus could, of course, be supplied from any inorganic and some organic sources. The calculations are not affected if another inorganic supplier is used but a considerable alteration must be made if an organic manure such as groundnut cake is used. The carbon nitrogen ratio of this and similar cakes is already approximately 5 to 1 and to balance this at the humus ratio of 10-1 only requires a further five pounds of carbon for each pound of nitrogen.

The 75 lbs. of carbon supplied per acre in the example given could be combined with 15 lbs. of nitrogen supplied by groundnut cake, i.e., 215 lbs. containing 7% of nitrogen.

The combination of nitrogen from artificials with the green manure has a very definite value in Ceylon tea manuring practice. The tea bush has no resting period comparable to that undergone by perennials in temperate climates or even with the tea grown in Northern India and a steady supply of plant food is, therefore, desirable. The process outlined is a considerable assistance to efforts in this direction for the nitrogen so held is gradually released by ordinary decay in the soil. Before this release takes place the nitrogen is protected from leaching to which it would otherwise be subject.

This process combined with the fact that the growth of green manure results in the removal of available soil nitrogen from possibility of loss, to be returned in the lopping, goes a long way to making possible an even supply of plant food to the tea bush.

The supply of inorganic nitrogen for the purpose of adding it to the stock of available nitrogen in the soil is not affected by the process under discussion. What is a reasonable supply for this purpose and the rate at which it will be absorbed by the tea and green manure trees are separate problems? The amount of inorganic nitrogen supplied in excess of the quantity which can be held in the green manure is an addition to the available nitrogen of the soil. As available nitrogen it is subject to loss in the form of leaching and obviously should be an amount which can be taken up by the roots of the crop in a very short period.

In the same way resistant forms of nitrogen such as some of those derived from fish or animal sources are not affected and the total nitrogen to be supplied per acre can be made up from the wide choice available.

A fairly typical mixture would on the above lines of construction be analysed as follows:

Green Manure available 4,500 lbs.

Sulphate of Ammonia 50 lbs.—Supplying 10 lbs. nitrogen for additions to the available stock in the soil and for immediate action.

Sulphate of Ammonia 25 lbs.—Supplying 5 lbs. nitrogen for interaction with 3,000 lbs. of green manure and additions to reserve stocks.

Groundnut Cake 70 lbs.—Supplying 5 lbs. nitrogen for interaction with 1,500 lbs. of green manure and addition to the reserve stocks.

Fish Guano 150 lbs.—Supplying 10·5 lbs. nitrogen in slow acting form.

Bone Meal 100 lbs.—Supplying 3 lbs. nitrogen in slow acting form.

It is not contended that such definite segregation would occur in practice. Each category of nitrogen is present in many mixtures of the same type as that instanced above and though it is actually impossible to attribute a particular fate to any one ingredient a consideration of the possibilities on the lines indicated seems worth while when a mixture is being constructed.

A mixture such as the one taken above would, when completed with the necessary potash, be a fairly common type and would approximate to a very large class of the mixtures in every-day use.

As these mixtures have been arrived at over a period of many years' manuring practice in Ceylon it seems that their correlation with the theoretical requirements is a confirmation of the theory propounded.

In many instances the mixing of nitrogen from various sources is now being given up largely on the ground of cost. The cheapest form of organic nitrogen costs more than twice as much as the cheapest nitrogen in an inorganic form and under the present conditions of stringent finance the change-over is to some degree inevitable. Mixtures are now being used which supply up to 50 lbs. or more of nitrogen per acre from entirely inorganic sources.

It has been commonly held that a liberal green manuring programme justified this course but even with a liberal allowance of green manure the danger of losing a very large proportion of this nitrogen is considerable under Ceylon soil and rainfall conditions. If we allow the high figure of 9,000 lbs. per acre of green manure only 15 lbs. of inorganic nitrogen can be held in a form which protects it from leaching, so that 35 lbs. must be regarded as being without the slightest protection from this form of loss until it is actually absorbed by the root system of the tea and green manure trees. In low rainfall areas at the drier periods of the year absorption by the root system will probably take effect, but the position must be a gamble on the rainfall for some time after application for even the highly retentive Rothamsted soils lose both ammonia and nitrates if heavy rain (for England) falls soon after application.

The use of organic nitrogen for the balance of the nitrogen supply after the satisfaction of the amount applied for immediate action and for combination with green manure cannot completely prevent losses as a long wet period may wash out nitrates as fast as they are formed by the breaking down of the organic nitrogen. Organics do however give some protection against loss and therefore justify their use. Though in the interest of economy the largest possible amount of inorganic nitrogen should be used the supply of nitrogen to the tea may be seriously curtailed if the factors set out above are not taken into consideration. The protection offered by simultaneous burying with green manure is considerable but is definitely limited and, valuable as the practice has been shown to be, it cannot be expected to protect the whole of the nitrogen in the annual supply if this is all in an inorganic form, so that the precaution of supplying some nitrogen in fairly resistant organic forms should be taken even though it involves some extra cost.

SMALL-HOLDINGS IN TEA

RECOMMENDATIONS OF SUB-COMMITTEE.

Recommendations of a Sub-Committee appointed by the Board of the Tea Research Institute.

1. The Institute to appoint a Small-Holdings Officer on a salary scale of Rs. 200-40-400 plus house allowance at Government rates so long as no house is provided.
2. A demonstration plot of about 10 acres to be leased in the Uda-Palata area and worked by the above Officer.
3. Subsidiary plots to be selected on small-holders' own land, to be worked by the small-holder under the general direction of the Tea Research Institute Officer. The Committee stress the importance of selecting the right type of small-holder for this purpose as the success of the work will largely depend on the personality and influence of the persons chosen.
4. In view of the fact that the question is largely an economic one, the Co-operative Society should be approached with a view to help being afforded towards the purchase of manures and other necessities.
5. Leaflets in the vernacular to be prepared for issue after demonstration work has been started.
6. Lectures and demonstrations to be given in bought leaf factories.

The above recommendations were approved in principle by the Board at its meeting on the 28th July, 1932, and financial provision was made for carrying them into effect.

SMALL-HOLDINGS IN TEA

C. H. GADD.

At the request of the Board of Management of the Tea Research Institute a short investigation into the conditions and methods of cultivation of Tea Small-holders in Ceylon was carried out during April and May, 1932, with a view to the making of recommendations for their betterment. As the small-holdings are scattered throughout the major tea areas, a thorough study of the conditions in all districts was impossible in the time available. Enquiries were made, particularly in the area between Nawalapitiya, Gampola and Kadugannawa where small-holdings abound, and in Kotmale where two of the recent Agricultural settlements are situated. From what can be ascertained on passing through other districts, and from conversations with those acquainted with the condition of small-holdings there, it would appear

that no great variation of conditions exist in the different districts, and that where variations occur they are usually of minor importance.

I am indebted to Messrs. H. A. Peiris, D. A. O., and C. N. E. J. de Mel, P. P. I. of the Central Division of the Department of Agriculture for conducting me through small-holdings and settlements in their districts, to the many planters, small-holders, tea traders, proprietors and teamakers of bought leaf factories who have supplied me with information, and to Ratemahatmaya U. B. Unamboowe of Kotmale for personally conducting me through the agricultural settlements of Waitalawa and Kottunugoda and for giving me the benefit of his wider knowledge of the village agriculturist and small-holder.

STATISTICS.

There are in Ceylon, according to the information supplied by the Department of Agriculture, 7,357 small-holdings of tea which embrace a total of 31,350 acres. An analysis to show the size and distribution of the holdings is appended to this report. It will be seen that included in the census are 252 estates of more than 20 acres, 62 of which are over 50 acres in extent. Many such properties are run on estate lines and cannot be regarded as small-holdings in the sense of the word it is used here. They appear to have been included within the census because they do not manufacture their own leaf.

The appended summary of the census shows that there are 2,983 holdings of one acre or less, 3,181 between 1 and 5 acres, 628 between 5 and 10 acres and 313 of over 10 but less than 20 acres in extent. They are distributed through the main tea areas of the Central, Uva, Sabaragamuwa and the Southern Provinces.

THE SMALL-HOLDER.

Usually the tea small-holder is the owner of the land he cultivates but in some cases the land is held on lease. Typically the man is a villager with agricultural interests. Frequently, he also owns other lands on which he cultivates other crops, especially paddy. Unless his land is sufficiently remunerative to support him and his family, he hires out his services as a labourer to neighbouring large estates or to other village cultivators. The man who works his own small-holding usually labours at times on tea estates, and in that way has become acquainted with the methods of cultivation practised there. There is, however, a large number of small-holders who always employ labourers on contract to carry out the major works in their tea gardens. These labourers are villagers who also are casual labourers on tea estates.

That the small-holder (or the labour he employs) also works at times on the neighbouring larger estates is of importance in that it affords an explanation of his knowledge of the methods of tea cultivation. He forms a definite connecting link between the large estate

and the village, and it is through this channel that information acquired directly or indirectly by the large estates is carried to the small-holdings. The small-holder, however, does not adopt all the methods of large estates in their entirety; this is not due to ignorance of such methods but is usually the result of other factors, mainly economic. It would be entirely fallacious to assume that the small-holder is an ignorant cultivator, he is intelligent and observant, though simple and at times indolent.

PLUCKING.

Commonly, the bushes are plucked by hired labour. The rate of payment varies in the different districts, but ranges from 1 to 2 cents per pound. At the time of these investigations the dominant rate in the Kadugannawa district was 1 cent per pound; $1\frac{1}{2}$ cents in Kotmale; and 2 cents in Balangoda and Haldummulla.

The necessity for careful plucking is well understood by the small-holder, and the present low price obtained for the leaf is undoubtedly impressing it well on his mind. There can be very little profit for the grower when good quality village leaf sells for 3 cents per pound, but, when the price falls to 2 cents or less as a result of bad plucking there can be no profit at all after his pluckers and other charges on his holding have been paid. Plucking was certainly coarser when prices were better. Judging from a demonstration given by a small-holder of the type of plucking prevailing when prices were booming, it was very coarse indeed, and at present would be unmarketable. Although the small-holder claims that the village plucker is very difficult to control regarding the standard of plucking, he appears to have achieved much in this direction.

The plucker, however, is not so much concerned with the price that the plucked leaf will ultimately command as with the weight of leaf gathered, because her pay depends upon that factor. Coarse leaf and immature shoots, independent of their position on the bush are likely to find their way into her basket or cloth. She will take shoots from the sides of the bush almost down to ground level and thereby tend to restrict the spread of the bush.

The bushes are plucked at irregular intervals—usually two or three times a month. The relatively long intervals between plucking rounds is partly the result of the removal of immature shoots by the pluckers. On all estates the necessity for close supervision of pluckers is recognised particularly where a regular round is adhered to during times of poor growth, e.g., during drought, to prevent the removal of immature leaf. The estate plucker is assured of her minimum wage no matter what short weight of leaf is brought into the factory but the village plucker's pay is determined entirely by the weight of crop she plucks. The result is that small-holder's bushes are stripped and there is an ultimate loss of crop.

The tea bushes on small-holdings do not flush so readily nor are they so large as the better cultivated bushes on larger estates. These factors tend to increase of time between pluckings.

PRUNING.

Bushes are not pruned at regular intervals but when in their owners' opinion they require it. In other words, pruning is carried out when the bushes "run out" and cease to yield further. The length of the interval depends upon the elevation of the holdings and the condition of the bushes. The small-holder himself appears rather hazy regarding the frequency at which he prunes his own bushes.

I saw no recently pruned tea, but on enquiry the method of clean prune was always explained and a previous pruning cut demonstrated. Even when there was evidence of a "cut across" having been used, the "clean prune" was usually described, and further enquiries were necessary to elicit the information that last time the bushes were "cut across". Wherever the "cut across" had been adopted, it was because certain adjacent estates pruned that way. The small-holder has not yet decided in his own mind whether the "cut across" is preferable to a "clean prune" though he no doubt finds the lower cost of the former attractive. He seemed rather puzzled that estates should have given up a method they had followed for many years. It is only when several estates prune on the new method that the small-holder will give it a trial. He is essentially conservative especially when he does not understand the reason for a change.

Twenty-five cents per 100 bushes appeared to be the normal rate of pay for pruners.

WEEDING.

The ground is weeded "when necessary". This is said to occur every 1, $1\frac{1}{2}$, or 2 months, but as a rule, it is not done till the weeds are thick and tall. Then the work is frequently put out at contract; the rate varying from Re. 1-00 to Rs. 3-00 per acre according to the amount of weed to be removed. Weeding is usually done with a scraper, sometimes with a mamoty, with the consequent loss of top soil on steep slopes.

DRAINS.

Many holdings are very inadequately drained, but where drains have been constructed they receive attention at intervals. The silt from the drains is commonly placed on the lower side though some holders place it above the drain, and a few claim to spread it through the tea. In a few well-cared-for holdings silt-pits in the drains were observed.

GREEN MANURES.

Green manuring is by no means a general practice. Where green manures are grown they are usually of the tree type, Gliricidia and Dadap being the commoner, because they are readily raised from cuttings which are easily obtained. Even in districts where these trees are easily established with little cultivation and where cuttings are easily obtained they are not as common as they should be on small-holdings. The bush type of green manure, e.g., Boga or Crotalaria, is very rare. That can be attributed to the fact that the land has to be prepared for the reception of the seed, which to the villager is expensive.

Green manure trees are often made to serve the dual purposes of firewood and mulch. Instead of taking 2 or 3 loppings per year as could be done in some districts, the branches are sometimes allowed to grow until very woody, so that they become more suitable for firewood. The production of vegetation for green manure is then to be regarded as of secondary importance to the production of firewood.

At the present time very few small-holdings bury either prunings or loppings owing to the high cost of burial and the low price of tea.

In the past, both prunings and loppings were said to have been buried in holes between the bushes. One labourer volunteered the information that he cut holes at Re. 1-00 per 100 and filled them at the same rate. Another small-holder who had given up burying his prunings for the last three or four years said that burial cost him up to Rs. 10-00 per acre. Now the leaves are left as mulch, but there was very little evidence of any mulch on the majority of small-holdings visited. Most of the leaves soon find their way into the drains or are carried off by the wind.

Cover crops are not used. A holding near Haldummulla was seen to be entirely covered by a creeping grass (buffalo grass) which was certainly efficacious in retaining the soil but no doubt was detrimental to the tea. His yield, from data he supplied, was calculated to be very little over 100 pounds per acre (made tea). A suitable cover plant would prove a boon to the small-holder as it would save his soil, tend to keep down his weeds and provide a certain amount of organic matter for his soil.

CULTIVATION.

Artificial manures are rarely used in small-holdings. Those few holdings which, mainly through the activities of Co-operative Societies, had previously used artificials have mostly abandoned them this year as uneconomic. A small-holder who manured last year expressed satisfaction at the result and offered the opinion that tea was well

worth manuring when the crop could be sold at 10 cents per pound, that it paid at 8 cents and possibly at 6 cents, but was unprofitable at the then price of $3\frac{1}{2}$ cents. Many small-holders, however, appear to regard artificial manuring as a rich man's hobby. "I am a poor man" was considered sufficient answer to the question "Have you ever tried the effect of manure on the tea?"

The soil is never disturbed except on the rare occasions when prunings are buried and during weeding. Forking is by no means a common practice, in fact, it is very rare. An increase in the use of artificial manures would also have a beneficial effect on the aeration of the soil, as if such were purchased they would certainly be forked in.

It will be realised that the small-holder attempts to maintain his bushes on the original reserve of plant food material in the soil. Little or nothing in the way of foodstuffs is applied to replace that taken away as crop or built into the bush. The consequence is that the bushes are small and in poor heart and the soil is steadily deteriorating.

PESTS AND DISEASES

Speaking generally, pests and diseases are probably less prevalent in small-holdings than in the larger estates. The holdings under present conditions cannot be regarded as a menace to large-scale cultivation through being centres of disease. Even the ubiquitous shot-hole borer is less prevalent there than in many cultivated estates, mainly, no doubt because the bushes contain less wood of suitable thickness to accommodate the borer.

CROP.

It is very difficult to arrive at any very accurate estimate of the crop collected by small-holders. No records are kept, but data in the following form is typical of what may be obtained: "80-140 pounds per plucking; 2, rarely 3 plucks per month; acreage 2 acres." These particular details were obtained from one of the best type holdings in the Ulapane district, and a pluck of 130 pounds was seen at the time of enquiry. Taking an average of 120 pounds twice a month a production of 360 pounds per acre of made tea can be calculated. The owner of this two-acre field held in all $6\frac{3}{4}$ acres, and as he sold his tea direct to a factory he was able to state his total receipts for the previous month, viz. Rs. 53-00. As the rate of payment was 5-$5\frac{1}{2}$ cents per pound the calculated yield is 500-600 pounds per acre made tea per annum. That month had been a good yielding month, so the calculated estimate for the year is undoubtedly high; it is higher than that calculated from the previous data.

The above figures are given to illustrate the difficulty in estimating yields from data available. Estimates based on an examination of the bushes by an experienced planter would possibly be more reliable. In the writer's opinion the average yield is well below 400 pounds per acre, a value estimated above for a good holding. An experienced planter in the Balangoda district, well acquainted with holdings in his neighbourhood, expressed the opinion that it could not be much above 200 pounds per acre. The yield varies with elevation and district, the condition of the holding and the percentage of vacancies. It is clear, however, by comparison with adjacent estates that the yields of small-holdings could be raised by suitable cultivation to at least 2 or 3 times their present amount.

DISPOSAL OF CROP.

The small-holder has little or no difficulty in the disposal of his crop; he sells either directly or indirectly to estate factories or to factories erected specially for the manufacture of his leaf, commonly termed "bought leaf" factories. The competition between bought leaf factories where small-holdings abound is very keen, and this competition ensures to some extent that the grower is not unduly exploited.

Between the factory and the small-holder comes the inevitable middleman or tea trader. Instead of having to carry his crop, may be a distance of several miles to the factory, the small-holder can sell it at a near-by boutique or collecting centre, where he obtains spot cash for it. The trader collects the leaf from his various centres and conveys it to the factory by bullock cart or other convenient means of transport. It is in the trader's own interest to get the leaf to the factory in the best possible condition. When the small-holder has to carry his leaf, as much as possible is crowded into the basket or bag in order to reduce the number of carriers; consequently the leaf arrives at the factory in a heated condition.

There is a standard difference of $\frac{1}{2}$-cent per pound between the prices paid by the factory and the trader. This may be regarded in the nature of transport charges. A small-holder, who transported his own leaf to a factory $1\frac{1}{2}$ miles distant, paid Rs. 2 per 100 pounds, i.e., 1/5 (one-fifth) cent per pound. At that rate for a load of 50 pounds the carrier would receive 10 cents for his 3 miles' journey. Taking into account that the trader's expenses are likely to include commission to boutique-keepers who use their shops as collecting centres, and that the distance of transport frequently greatly exceeds $1\frac{1}{2}$ miles, the rate of $\frac{1}{2}$-cent per pound does not appear excessive.

The small-holder is fully aware that he can receive a higher price at the factory door than from a trader, yet, even when his garden is close to a factory, he frequently prefers to sell to a trader. The

reason for this is that the trader pays cash at the times of sale, whereas the factory runs a monthly account. Moreover, the trader will usually advance money on the crop, and this fact is made full use of.

It will be readily understood that a factory will prefer to buy a single large quantity of leaf than numerous small amounts. The pluckings from very small gardens will consequently be unpopular at the factory and steps may be taken to force the sale to a trader who will collect and sort the smaller quantities before bringing them to the factory as one consignment. This view is supported by the fact that bought leaf factories in the past advanced money to traders, though I understand that this practice, owing to financial stringency, is now ceasing, and that some factories employ their own collecting agents. The managers of bought leaf factories, however, emphatically denied that they ever refuse to buy small quantities of leaf from a small-holder if it is in good condition.

OPENING NEW LAND.

Except on the new agricultural settlements such as those at Kottunugoda and Waitalawa, in Kotmale, which I visited with the Divisional Agricultural Officer, Central Division and the R.M., Kotmale very few small-holdings are being opened in tea. The settlements I saw are divided into 1-acre blocks, $\frac{3}{4}$ of which are being opened in tea; and the remaining $\frac{1}{4}$ acre is used for the growing of vegetables, fruit trees and for the house site. As there are numerous applicants for such blocks of land some selection can be made to obtain a good type of settler. The Agricultural Instructor of the Department of Agriculture and the R.M., Kotmale had taken great interest in and had supervised the work of opening these lands. The R.M. is an enthusiast with agricultural interests and it is the effect of his influence that can be observed in the holdings. The Agricultural Instructor is keen, a hard-worker with a sound knowledge of his work, but it was noticed that a word from the R.M. had a greater effect than a lecture from the Agricultural Instructor. This is not intended to convey a criticism of the Agricultural Instructor, but to indicate what, in my opinion applies to most districts, namely that the work of an Agricultural Instructor must have the backing and support of the headman if it is to prove effective.

The acre of land even when in full bearing is never likely to be sufficient to maintain a settler and his family. To supplement the income from the holding even when it is in full bearing the men will have to obtain employment on neigbouring estates. They are experienced labourers and to a certain extent have adopted the methods used on estates where they work. Where they deviate from such methods it is not through ignorance but as a result of economic impulses.

The seed is planted at stake after the land has been cleared and holed at a distance of $3 \times 3\frac{1}{2}$ feet. Usually a catch crop of manioc is taken during the first year. A good deal of remonstration from the R.M. was necessary to prevent second and third crops being taken, though the holders knew that the growing of such would be detrimental to the tea.

The same economic impulse is to be seen in a tendency of some of the holders to hard pluck the young bushes. In a few cases the the bushes were severely plucked, almost stripped for some time before they were centred. As a rule, they were centred at about 4 inches when about 3 years old. After being centred the bushes are likely to be taken into bearing when grown sufficiently high. One settler had centred his bushes when they were 18 months old; the bushes were ready for a first prune at 3 years after which they are to be taken into bearing. This method appeared to be very suitable for that soil and elevation, and in my opinion was more suitable for the small-holder than centring after 3 years' growth, which appeared to be commoner practice.

It was evident, however, that even the R.M's. influence was not sufficiently great to prevent the worse type of cultivator from stripping his unpruned tea. The small-holder may be a good agriculturist but he is a poor economist. Apparently, he finds the appeal of a few cents he will get for the strippings of his young tea irresistible It is not because he is destitute. He can earn sufficient on neighbouring estates to maintain his family and yet have time to cultivate his holding, in the work of which he is ably supported by his women folk. It is a great pity that he is so often so short-sighted that he cannot see the injury he is doing to his bushes by such premature plucking.

The plots are drained and in many cases silt-pitted. Paspalum, and in some cases Boga as well, has been planted on the edge of the drains. The paspalum is cut as fodder. Green manure trees such as Dadap, Albizzia and Grevillea are to be seen in every holding. Indigofera is being propagated from the few plants there. The tea plants on the majority of holdings are about 3 years old and well grown; the stand is uniform and there are few vacancies.

The presence of shade trees is not due solely to the holders knowledge that they are good for tea, but to a large extent to the activities of the R.M. He has established a nursery where these trees are raised and they are sold for small price to the cultivators. A tree paid for, even though it cost but half-a-cent, is likely to be better cared for than one acquired without effort.

The standard of cultivation throughout and the condition of the holdings are in general of a much higher standard than those seen in many villages. One excellent holding I noticed had stone terraces in places above the drains; another had recently been forked throughout, though no artificial manure had been introduced with the fork for financial reasons. Some holders had erected serviceable permanent houses, whereas others were satisfied with erections of a more temporary nature.

LEASE-HOLD.

The terms on which tea land is leased to the small-holder affords some indication of the agricultural value of the land and the attitude of the owner towards his permanent crop plants. It was ascertained that near Kadugannawa a few years ago, tea land could be leased for Rs. 10-00 to Rs. 20-00 per acre. At the present time, the small-holder can obtain for Rs. 10-00 per acre, what previously he had to pay Rs. 20-00 per year for. That is not due so much to the deterioration of the yielding capacity of the bushes as to the present depressed state of the tea market.

The terms of the lease are generally very easy. The lessee undertakes to maintain the boundaries and drains, and to keep the land clean by weeding once a month. Apart from such agreements he is free to cultivate the land as he chooses. He can exploit the land and the tea bushes on it to the fullest extent. There is no standard of fertility to maintain, and there is nothing to prevent continuous stripping of the bushes.

Though there is nothing in the lease to prevent the lease-holder from extracting the last cent out of the land and bushes without putting anything back, one cannot tell from a survey of a plot whether it is cultivated by the owner or held on lease. That this should be so may be explained on two hypotheses. First, an innate sense of honesty prevents the lessee from unduly exploiting the holding. Second, that both owner and lessee regard the existing methods of exploitation of a tea garden as sound, both agriculturally and economically; their object is to get as much as possible from the garden with a minimum expenditure of money and labour. The villager appears to live for the day; he apparently makes little provision for the future, so the second hypothesis is probably sound though the first is not to be ignored.

FINANCE.

The great majority of small-holders have no working capital and practically the whole of the income from the holdings is applied to the owner's maintenance and personal needs. Any expenditure on the garden whether it be for cultivation or manure has to be very

carefully considered. A small-holder who spends the day on a large estate forking the soil receives his day's pay, whereas if he spends the same amount of energy on his own holding his immediate return is nil, and his ultimate return is at best problematic. Possibly he has found from experience that forking alone, without the application of artificial or green manures, is not economical. His view appears to be that only the rich man can afford manures and that he would use them too if he could afford them. An increased use of fertilisers would probably lead to better all-round cultivation.

Co-operative Societies have done much to assist the small agriculturist by obtaining and advancing manures to members. Investigations into the operations of Co-operative Societies would show the extent of their work in this direction. A village society last year is said to have disposed of 3 tons of manure to small-holders at Rs. 7-50 per cwt., and but for the depressed state of the tea market, its activities in this direction would probably have increased. The tea trader also will advance manures and refund himself from the proceeds of the crop as it is sold to him. It is a matter of indifference to many traders whether the money advanced is expended on the improvement of the holdings or on private festivities; they are assured of their return through the crop on which they have advanced money. It is, therefore, easier for a small-holder to obtain an advance from a trader than from a Co-operative Society, which does not trade and which will make enquiries regarding the purpose of the loan before making it.

The question of mortgages and other methods of raising money need not be considered here. The finances for the improvement of a holding should be obtained from the income derived from that holding, if it is in bearing, or from money obtained by labour outside, if it is not in bearing. For this reason lands granted to settlers under the recent Government Settlement Schemes cannot be mortgaged.

GENERAL CONSIDERATIONS.

The village cultivator is like most agriculturists essentially conservative in outlook. He treats his crops as his father and forefathers did before him, he knows that the methods have stood the test of time and his practices have been built up from the experience of ages. He will listen patiently to the theorist but no amount of argument alone will cause him to change his methods. That stubbornness is, however, not to be mistaken for ignorance; he is, in the writer's opinion, both observant and intelligent.

It may be difficult to reconcile this view with many of his practices in tea cultivation. To him, tea is a new crop, he has not the knowledge of his forerunners behind him and consequently he is not so sure of himself. He, therefore, turns to the practical planter for

advice and not to the theorist. He watches closely the methods used on estates and will work on the estate if necessary to acquire a better knowledge of a method he intends to use. A change in the method of pruning on a neighbouring estate is not passed unobserved. If other estates make a similar change the small-holder will change his method too. He will follow on the assumption that if a number of large estates change their method there must be good reason for it. On being asked why he has changed from a "clean prune" to a "cut across" a small-holder will reply that he has done so because such and such an estate now prunes that way. He may not know whether it is a better method for his purpose but he can usually name a number of estates that use that method. He is observant and is quick to appreciate advantages (if any), as may be instanced by the small-holder who concluded that the "cut across" was the better method because he noticed fewer deaths to occur after pruning. In such a way, a knowledge of tea cultivation is acquired by the villager, the methods of large estates are followed first and the experience gained is added to their own fund.

It does not follow that because a large estate does a certain thing the small-holder will necessarily follow, otherwise why is manuring, green or otherwise, so rare on small-holdings? Here the question of cost comes in. There are certain operations which are absolutely essential for the harvesting of the crop, e.g., pruning, and in these the small-holder quickly follows the methods of large estates. Others, such as green manuring, are not essential—the bushes will yield some crop whether they are manured or not and in these it is the matter of immediate cost which frequently determines whether the practice will be followed or not. As regards green manures, seeds or cuttings have to be obtained and tea land has to be prepared for their reception; after some time when the plants have grown sufficiently large, they are lopped and the loppings have to be buried. Each of these steps requires money or labour, and what is the immediate visible result on the tea? When will the cultivator be reimbursed for his expenditure or labour? No amount of lectures or propaganda will cause the small-holder to change his attitude, the return is too slow and not sufficiently visible to the eye.

One has also to take into consideration the villager's general attitude towards perennial crops, whether tea, rubber, or coconuts, and compare it with his treatment of annual crops such as paddy or tobacco. The latter have to be cultivated and the harvest, taken a few months after sowing, has a direct relationship with the class of cultivation. Poor cultivation will result in a poor crop, that is the experience of the ages and clearly understood. A perennial crop, however, is not so dependent upon cultivation; the tree will continue

to yield whether it is cultivated or not. Wild trees are left alone, yet they annually give their harvest. That is the most obvious part of nature's lesson. That the harvest might be greater if the trees were cultivated may not be disputed, but it is doubtful whether the small-holder has realised the profit resulting from good cultivation.

Tea is probably the most heavily manured perennial crop grown in Ceylon, and it has achieved that position because such treatment has proved profitable. Yet the small-holder has rarely manured his tea. This is mainly because he demands a quick and visible return. The nature of the tea crop debars this. The bushes are plucked 2 or 3 times a month and any increase in crop resulting from the manuring is not collected in one harvest but bit by bit through the year. The cost of his manures and the application of them is paid in rupees, but his return arrives by instalments in cents. His profit is not immediately visible and is not easily calculable in the absence of records, so some doubt must exist in his mind that a profit has resulted.

If the small-holder suspects that cultivation might prove profitable his financial position frequently is such that he is hesitant to experiment. That he requires the proceeds from his crop for his immediate requirements is seen in the fact that though near a factory he will sell to a trader rather than directly to a factory which pays at a higher rate, but monthly. Advances obtained from a trader are rarely used for the production of the crop on which the advance has been made. So long as that financial condition prevails the probability of improving the methods of cultivation are remote.

AGRICULTURAL INSTRUCTION.

Agricultural instruction to villagers is not merely a matter of the teaching of theory or the particular use of tools or special methods; it is more a question of personal contact, mutual respect and a complete confidence in the integrity and knowledge of the instructor. An instructor who is personally known to the villager and respected by him will have a much greater influence and will produce more lasting and beneficial results than can an itinerant lecturer with his occasional talks.

If this view is accepted it follows that a number of good instructors each capable of advising on questions dealing with all agricultural crops and each working over an area, the size of which admits of personal relations between instructor and agriculturists will do more sound work than could an equal number of instructors, each specialist in a particular crop but working over the combined area. In the latter case not only would the work be productive of poorer results but the difficulties of administration and the cost of travelling would be enhanced.

Agricultural research work in Ceylon has been apportioned to specialist research stations, of which the Tea Research Institute is one. Though in many respects it is advantageous to separate research work on Tea from those on Rubber and Coconuts or other crops, it is not equally advantageous to split village agriculture into similar specialist divisions. A small-holder of tea frequently cultivates other land for other crops, such as paddy, and it is obviously preferable that such a man should have one agricultural instructor than that he should apply to different instructors for advice on the different crops he cultivates.

Instruction in village agriculture, of which the cultivation of tea is a part, is essentially a function of a benevolent Government. This work is at present in the hands of Divisional Agricultural Officers of the Department of Agriculture under each of whom is a number of Agricultural Instructors. Each instructor is allotted a definite range with a village or town as headquarters. His duties are numerous and his range in many cases unduly large, but his purpose is to give agricultural instruction and to improve village agriculture in every way within his power.

That service has been in operation for several years and much useful work has been done through it. If further extensions in agricultural instruction are to be made they should be directed towards the strengthening or augmenting of the existing service and not towards the replication of it by individual research stations.

Such a view does not imply that the Tea Research Institute should take no part in the instruction of the village agriculturist concerning the methods of tea cultivation. Much assistance can be provided not only indirectly by courses of instruction to agricultural instructors as outlined in the recommendations but also more directly by means of demonstration plots as indicated on page 104. The work of any officer employed by the Tea Research Institute under any scheme of demonstration should be supplementary to the present work of the Agricultural Department regarding tea and not as a replacement or substitution for that work.

DEMONSTRATION PLOTS.

As a small-holder normally learns more readily through the eye than through the ear it should follow that demonstration plots must form a suitable means of instruction. One has, however, also to bear in mind that every estate is virtually a demonstration block for neighbouring small-holders.

During the course of these investigations, the writer had the good fortune to see two blocks, which in many ways, were model demonstration plots. One, situated on the Waitalawa Agricultural

Settlement was maintained by the Ratemahatmaya of Kotmale purposely as a demonstration plot; the other was an area of about 2 acres situated between Kadugannawa and Peradeniya, leased by a tea trader, and cultivated for his own purposes.

The R.M's. block is in every way the same as those of the ordinary settlers. It was opened at the same time and the methods used there are reflected throughout the whole settlement. The plot is drained and silt-pitted, green manures of both tree and bush types are grown, and Indigofera is being tried as a cover crop. The majority of the holdings in that settlement are in like condition. Yet in the adjoining holding, at the time of my visit, stood well-grown 3-year-old plants ready to be cut back, which were being plucked hard, despite the remonstrations of the R.M. and Agricultural Instructor.

Taking the whole settlement into consideration, it would appear that the demonstration block had a marked beneficial influence. That may not be disputed, but personally I am inclined to attach more importance to the R.M's. personality and influence than to his demonstration block alone. He was good enough to conduct me personally around the Kottunugoda Settlement which is also under his charge. There he had no demonstration block, yet the condition of that settlement was as good, if not better than that at Waitalawa. I judge that his active interest, the high respect in which he is held, plus a certain amount of the authority with which he is invested has done far more good than could any demonstration block alone without these personal attributes.

The tea trader's holding was old tea, well-drained, silt-pitted and artificially manured. The bushes were in excellent condition and evidently yielding well. The holding was in very good order and an excellent demonstration to surrounding holders. Yet, adjoining it on one side was a typical small-holding which perhaps showed up badly by contrast as there was no prominent boundary between the two blocks. The holding on the other side was drained and had silt-pits in the drains; of the latter the owner appeared quite proud. He also grew a few green manure trees, but there the effect of demonstration appeared to cease. I asked this small-holder, who had shewn me the tea trader's garden if he had ever tried artificial manure himself. He replied that he was a poor man and that with the present price of tea one could not afford manures. In boom times, when he had been getting as much as 20 cents per lb. for his leaf he was quite satisfied with the income from his garden, so had not tried manures then. He knew nothing of the profits which result from artificial manuring.

The trader unfortunately was away from home, but from a conversation with some people at his house, I gathered that he was a leading spirit of a Co-operative Society. This society last year induced 10 cultivators to apply manure to their tea. My informant said that all the cultivators were satisfied with results, but owing to the present price of leaf they had discontinued manuring. One who had applied manures previously, but had now stopped, gave me the figures quoted earlier. These observations illustrate the limited sphere of influence of, and the poor results to be obtained from, a demonstration plot compared with the effects of personal influence of keen enterprising cultivators.

Special plots to demonstrate agricultural operations such as weeding, forking, pruning and plucking are valueless to a man skilled in such operations. As the work on the majority of small holdings is done by labourers who have learned their work on large estates, it appears no more necessary to demonstrate such operations to the small-holder than to normal estate labour. Both labourers have learned in the same school.

Plots to show what shade, green manure or cover plants will grow in the different districts also have a very limited value. The small-holder when interested in these subjects is more likely to follow the practice of large estates where such plants are grown on a large scale. It is a waste of time for a small demonstration plot to exhibit in its limited space all the various trees and plants to be seen on neighbouring estates.

The main thing to demonstrate is how to make a profit, but I have yet to see a demonstration plot which does that. That certain methods of cultivation and manuring lead to the production of better looking gardens and finer tea bushes must be obvious to all small-holders. They are fully aware that such methods demand money and labour, which they can estimate fairly accurately, but they appear to be entirely ignorant of the returns obtained from the use of these methods. If demonstration plots are to serve their best purpose some method of demonstrating profit-making should be undertaken.

SUGGESTIONS.

The amelioration of small-holdings is not so much a matter of instruction in the art of agriculture as it is of economics and finance. Agricultural instruction alone can benefit the small-holder but little. He is skilled in agricultural operations and is aware of that skill; his instruction should be of a more general and personal nature, and along broader lines.

INSTRUCTION.

That instruction in village agriculture, including tea, is essentially a function of the Agricultural Department has been shown earlier (Agricultural Instruction). In this work the Tea Research Institute

could materially help by organising courses of instruction and refresher courses for agricultural instructors stationed in tea districts. Through these and by conferences, the instructors could be kept acquainted with the results of the work of the Institute, and opportunity would be afforded for the discussion of problems particular to small-holdings.

The small-holder at present learns from the larger estates, and he acquires a knowledge of more modern methods only after the large estates are convinced of their practicability. There is, therefore, some delay in the transmission of information to him but this delay is not altogether disadvantageous. The fact that he gets his information from large estates ensures that the methods are practicable and not merely theoretically sound; he also learns in a manner with which he is best acquainted, viz. visually.

Conferences between research officers and agricultural officers would afford opportunities for the explanation of the theory underlying new methods and for the demonstration of these methods. The Agricultural instructor would thus form a definite *liaison* between the T. R. I. and the small-holder, and be in a position to explain and demonstrate new methods and discuss the suitability or otherwise of such methods to the small-holders' particular needs.

The instructor should be allowed to communicate direct with staff of the Institute on matters relating to their work with tea. This would allow of individual problems relating to small-holders being brought early to the attention of the Research Officers concerned, and of available assistance being afforded immediately. The instructors, however, would remain entirely under the jurisdiction of the Department of Agriculture; the Institute would have nothing to do with their work or their disposal, except in so far as it is possible to keep them fully acquainted with improved methods of tea cultivation.

LEAFLETS.

The distribution of leaflets or pamphlets in the vernaculars at present can serve little purpose. Such articles would necessarily have to be written in general terms; and the villagers would have to sort out the answer to his particular problem from a mass of generalities. The vehicle of instruction is unsuitable, in some cases, if the leaflets are broadcast in the absence of demonstration; in others, the instruction would be useless unless the problems of finance and of the supply of necessary requisites are previously solved.

DEMONSTRATION.

The value of demonstration plots has been discussed earlier where it was pointed out that their main object should be to demonstrate how the gardens may be made more profitable. If this could

be done, it seems probable that beneficial results might be achieved by such plots.

The best results are likely to be obtained where the demonstration plot is a typical holding run by a progressive small-holder of suitable personality, character and influence, preferably one who himself works in his holding. Thus the object of the plot would be to demonstrate that a small-holder can make an increased profit, and not that a Government or an Institute, which to the villager is assuredly rich, can make an enhanced profit from a small-holding. This point is of importance because a plot owned by a wealthy body is not very different from normal estates which already serve as demonstration plots in many respects.

The selection of small-holder demonstrators must be carefully made. In this, revenue officers, headmen and agricultural officers might assist, possibly their services would be very necessary, but no great difficulty need be anticipated in this matter.

The small-holder would have to undertake to work this holding as instructed by a supervisor. He should be assured of a certain increased income from his holding, or alternatively, he should be guaranteed against all loss resulting from the use of special methods. The former method would appear to be the simpler in operation. It should be possible to estimate what increased yield is likely to accrue from the special treatment, from which can be calculated after deduction of the cost of manures and other like expenses, the amount of expected increase of the holding's income. An assured income plus any profit which could be made in excess would appeal more strongly to the villager than a problematic profit only.

The object in view is to demonstrate to selected small-holders that proper cultivation of tea pays. Success would soon become common talk in the villages and others would be more ready to try. By success is here meant that the plot owner has obtained from his holding an increased income which more than paid for the requisites and labour, and that the demonstration has, therefore, been carried through without any cost to the organising body other than the supervisor's salary and travelling expenses. The cost of the operations and the amount of crop collected, together with any previous record available, would be posted prominently on a board near the entrance to the plot, so that visitors may see what the improved condition of the holding had cost and what profit had resulted therefrom. This would also advertise the success of the operations and give the surrounding small-holders cause to think.

At the same time it must be realised that a failure would be equally well advertised and that a failure will probably do more harm than a success will do good. For this reason it is probable that the

present is not the best time for initiating such demonstrations, as many estates are finding it difficult at present market rates to show a profit under any system of cultivation. As market conditions improve it should be possible to organise demonstration plots along the lines here briefly outlined.

Precautions would have to be made for the checking of expenditure and income. The expenditure and quality of work done could be checked during periodic visits by the supervising officer, and if the crop is sold to a certain factory or trader, a check on the out-turn could be obtained through that agency.

Demonstration plots somewhat of the type here envisaged would serve a useful purpose. Progress would be slow at first but what is effected is likely to be permanent. If successful the sole costs would be those of supervision and the travelling expenses of supervising officers.

FINANCE.

The amelioration of small-holdings cannot be alienated from the problem of financing the village cultivator. This is a difficult and complex matter which has occupied the attention of others more qualified to solve the problem than I am. Co-operative Societies constitute an important part of the answer to the problem, and their work should be given every encouragement. An extension of their work along the lines of co-operative trading might prove of value.

It should be realised that a small-holder, should he desire to use artificial manures, is not in a position readily to obtain them. If he is a member of a Co-operative Society he may get assistance there; otherwise he must go to a village trader to obtain his supplies. Although the small-holder, while working on a large estate, may at different times have spread many tons of manure, he is unacquainted with the constituents of the mixture. He, therefore, rarely knows what he wants as manure, and the trader is in little better position to advise him. The trader will obtain a manure for him and possibly advance the money for the purchase of it, but it is questionable whether that is the best source of supply for the small-holder.

The problem of finance cannot altogether be dissociated from the question of the provision of agricultural necessities. A trader is in a better position to supply both funds and requisites than is a Co-operative Society, because he can reimburse himself for any advance of money or supplies by means of the crop, which the borrower must sell to him. A manure can thus be bought with tea leaf by instalments, but the advantage is mainly with the trader, who makes profits on the sale of the manure and tea leaf, in addition to

his interest on the loan. The trader could to some extent be displaced by co-operative trading, and a movement in that direction by existing Co-operative Societies would probably prove beneficial. The work of collecting and transporting the leaf to the factory could possibly be done co-operatively at less than the trader's margin of half-a-cent per pound; suitable manures could be advanced against the crop, and possibly the factory would finance the Society for this purpose in much the same way that it has advanced money to tea traders in the past.

MANUFACTURE.

The small-holder is not interested in the question of manufacture, his interests cease with the sale of his green leaf. All factories, whether estate or bought leaf, can at present obtain the assistance of the Tea Research Institute in the improvement of their methods of manufacture, and no special steps appear to be necessary to deal particularly with the manufacture of village leaf.

The association of those interested in the manufacture of bought leaf, such as that which has recently taken place at Kadugannawa will afford a simplified means of communication between the T. R. I. and bought leaf factories. Also, should the members of such associations desire it, members of the Research Staff of the Institute could address them on appropriate subjects.

28th May, 1932.

SUMMARY OF SMALL-HOLDINGS CENSUS.

	Acres.	Number of Holdings. Total	1 acre or less	1-5 acres.	5-10 acres.	10-20 acres.	20-50 acres.	Over 50 acres.
CENTRAL PROVINCE.								
Kandy District.								
Yatinwara	1295½	405	132	221	31	17	4	-
Harispattuwa	631¾	162	52	87	14	7	1	1
Uda-Dumbara	741¼	325	49	253	16	6	1	-
Uda-Palata	3206¾	1575	814	640	79	27	14	1
Uda-Bulatgama	381½	1088	455	510	72	27	21	3
Matale District.								
Matale South	603¾	194	91	74	16	11	2	-
Matale East	76¼	17	4	8	4	1	-	-
Nuwara Eliya District.								
Kotmale	1766¼	561	300	171	62	20	6	2
Uda-Hewaheta	983	190	25	119	26	13	7	-
Walapane	178	36	11	17	4	2	2	-
TOTAL	13304	4553	1933	2100	324	131	58	7
UVA.								
Udukinda District								
Udukinda	4784½	1173	509	476	106	49	24	9
Yatikinda	1551¾	136	34	16	12	9	13	8
Wiyaluwa	368½	26	5	13	5	-	-	3
Buttala	5	1	-	1	-	-	-	-
Wellawaya	336½	33	2	13	7	6	2	3
TOTAL	7246½	1369	550	563	130	64	39	23
SOUTHERN PROVINCE.								
Galle District.								
Bentota Walallaurti K.	392	38	3	19	7	4	4	1
Wellabada Pattuwa	368¼	42	7	15	10	4	6	-
Four Gravets	183	7	-	-	1	2	4	-
Talpe Pattuwa	748¼	103	27	37	18	10	10	1
Gangabada Pattuwa	1879½	456	212	174	24	26	16	4
Hinidum Pattuwa	20	1	-	-	-	1	-	-
Matara District.								
Morawak Korale	4374	424	165	125	54	35	27	18
Weligam Korale	191½	23	4	11	2	3	3	-
TOTAL	8156½	1094	418	381	116	85	70	24
SABARAGAMUWA.								
Ratnapura District.								
Kuruwita Korale	283	8	-	2	2	-	2	2
Nawadun Korale	603	65	15	26	10	7	3	2
Kukulu Korale	43	2	-	1	-	-	1	-
Balangoda Area	1201½	184	57	78	25	9	12	3
Kegalle District	712	82	10	30	21	17	3	1
TOTAL	2842½	341	82	137	58	33	23	8
GRAND TOTAL	31549⅓	7357	2983	3181	628	313	190	62

DIEBACK.

F. R. TUBBS.

The dying back of a varying number of branches after pruning is a well-known phenomenon, particularly at lower elevations, where it is frequently so severe as to result in the death of the entire bush. In districts where this is a common experience it is customary to expect the loss of a percentage of bushes after pruning, the percentage being found to vary according to the severity of the pruning method employed. It is of importance, therefore, to determine more accurately than is possible on an estate, the extent to which variations in the type of pruning affect the amount of dieback and the number of deaths.

An experiment was designed for this purpose and carried out on Galatura Estate in the Kiriella district in a field of high jât tea about 200 feet above sea level, the area being pruned at the end of April, 1932. Three methods of pruning were tested. The first was clean pruning three inches above the previous clean prune level, the second rim-lung pruning in which up to six lungs were left on the edge of the bush, small bushes having fewer lungs in proportion. The third method was cut-across pruning at the same level as the other two treatments, no small wood or twigs being removed below the pruning level. It should be carefully distinguished from a Travancore prune, which is pruned *above* the tipping level of the previous prune and is therefore considerably lighter in nature.

The three treatments were randomised in six blocks, each block containing each of the three treatments once only. There were, therefore, a total of eighteen plots, (each consisting of two hundred and fifty bushes) divided up into six blocks. Since each *block* contains one plot of each treatment, the differences in the total amount of dieback between different blocks will be due to differences in the environment of the different blocks, and not in any way to the methods of pruning employed. The differences between the plots situated within one block will be due to differences in the effect of the different prunings, since environmental conditions may be assumed to be uniform within the compass of a single block. The application of a method of mathematical analysis, known as the "Analysis of Variance" to the results enables the significance of the observed differences between blocks and between treatments to be gauged.

The numbers of dead bushes at the end of three months after pruning are shown in Table 1 from which it will be seen that, of a total of one thousand five hundred bushes in each treatment, sixty-seven or 4·47% died after clean pruning, while twenty-seven or 1·80% died after cut-across pruning. The rim-lung treatment resulted

in the fewest number of deaths, namely eight or 0·53%. Statistical analysis shows that the clean prune treatment results in a significantly greater number of deaths than either of the other two treatments, but the difference between rim-lung and cut across is not significant. The difference between blocks is also not significant.

The amount of dieback was determined by performing a careful secondary prune at the end of July, 1932 to remove all dead material, which was collected from each plot separately and weighed. The results show that a total of 346 lbs. were collected from the clean pruned plots against 130 pounds from the rim-lung plots and 227 from the cut-across plots (Table III).

The question arises as to whether only the pruning treatments used have influenced the amount of dieback, or whether the differences in the environmental conditions associated with different blocks also have an influence—in other words, does the *position* of a bush in a field have an influence on the dieback shown by it, in addition to the effect of the type of pruning employed? In Table II the weight of dieback in different blocks is given, the figures showing that large differences exist between the different blocks.

It therefore appears that both pruning and environmental conditions affect dieback. The application of the Z test to the results of an analysis of variance shows that the differences observed between pruning treatment totals, and between block totals are in fact real and cannot be considered to be the result of fortuitous circumstances. The chance of the observed differences being accidental is less than one in a hundred in each case.

The differences between the three pruning treatment totals are examined in relation to the standard error of the difference of totals of six plots, the value of which is 32·10 lbs. Differences between totals (Table III) of more than twice the standard error (i.e., more than 64·2 lbs.) may be adjudged to be real and not accidental. The test shows that the difference between each pair of treatments is real.

The evidence gained so far may be briefly summarised thus:

(a). Clean pruning results in more deaths than rim-lung or cut-across.

(b). The amount of dieback caused by clean pruning is greater than that due to rim-lung or cut-across pruning, and cut-across pruning causes more dieback than rim-lung pruning.

(c). The amount of dieback is influenced by environmental conditions.

These results fall into line with the evidence given by Gadd [1] that death and dieback after pruning was due to a deficiency of starch reserves in the roots, the removal of the whole of the carbohydrate

manufacturing apparatus (the leaves) resulting in the bush being unable to produce new leaves and shoots. He suggested that "a very light form of pruning should also be practised in affected fields. . . . . The object is to leave as much leaf as is possible on the bush, so that the manufacture of food supplies may be carried on without a break." On this theory of the causation of dieback, it was to be expected that methods of pruning which varied in the extent to which the bush was deprived of its leaves would vary in the amount of dieback caused. It is interesting to note that the number of leaves left on after pruning were found to be:—

Clean prune	3·0	Means derived from 240 bushes in each treatment.
Cut across	41·6	
Rim lung	200·5	

The results described above, however, suggest that other reserves in addition to carbohydrates may be of importance. It is well known that the yields of flush vary in different portions of the field, and the results of a well-organised field experiment upon yields are expected to show this. But the fact that the amount of dieback shows a positional variation similar to that found for yield suggests that the amount of carbohydrate reserves (e.g., starch) present in the bush may not be the only factor affecting dieback, and that the factors which affect yield also affect the amount of dieback.

The blocks are all of the same jât. It is unlikely, owing to the lateral spacing of the plots across the slope of a hill, that aspect has affected dieback. It is more probable that the actual fertility of the soil is the factor concerned in this connection, especially since the greatest dieback occurs in those blocks which yielded least in tippings (Table II) although a portion of this effect may be due to the effect of dieback on tipping growth.

The fertility of the soil is the final resultant of a very large number of factors, including the many elements necessary for plant growth and the factors concerned with physical condition of the soil. It is, therefore, rather difficult to select any particular aspect which may be regarded as typical of fertility, but it is usual to consider as foremost the three principal manurial substances, potash, phosphorus and nitrogen.

Lincoln and Bennett [2] examined the distribution of total nitrogen in pear trees and found that the percentage present in the branches and roots was lowered considerably during the summer i.e., when foliage production was making demands on the nitrogen present in the stem, while Thomas [3] showed that large amounts of nitrogen are stored, chiefly in the one-year-old wood, in the autumn. In other words, a form of storage during periods of slow growth can occur in the case of nitrogen as well as of carbohydrates. It is probable that similar phenomena occur with phosphorus and potassium, and one

is led to the view that the amounts of mineral substances present in the bush before pruning may be of considerable importance in relation to dieback. Figures are not available on the compostion of the tipping growth at Galatura, but information on this subject has been obtained at St. Coombs. The percentage of total nitrogen in the young growth at the time of tipping was 2·796, the amount localised in the young growth of one bush being 2·016 grammes. At three thousand bushes to the acre, this gives a figure of thirteen and one-third pounds of nitrogen per acre. It is a moot point what proportion of this is absorbed from the soil during recovery from pruning, but one may assume that a large proportion of it is originally removed from the root reserves, the deficit in the root being made up as absorption from the soil continues. These figures illustrate the drain upon the root reserves which accompanies the recovery of the bush from pruning.

It is probable that the fertility of the soil influences the amount of carbohydrates produced by the plant previous to pruning, and, in fact, it is known that potash does exercise an influence upon this process. The block variance previously referred to may be considered as due to a combination of the effects of fertility directly, and also indirectly via carbohydrate reserves, upon dieback.

The conclusion to be drawn from the above evidence is that at elevations where dieback is frequent, rim-lung pruning offers great advantages. On poor areas a very generous provision of lungs is advisable, since the lungs will remedy any deficiency of carbohydrates, and may conceivably, judging from the results obtained from experiments upon temperate fruits, also supply a certain amount of mineral elements to the growing shoots.

It may be objected that in the present state of low-country tea, the extra expense of rim-lung pruning must be considered. The only extra expense, a small one, involved is that of cutting back the lungs at or near tipping time. The amount spent will vary with the method used, but in any case cannot amount to anything approaching the capital cost of bushes saved. At three thousand bushes to the acre, and cts. 50 per bush, the saving by using rim-lung instead of clean pruning in this case works out at Rs. 59-00 per acre.

REFERENCES.

(1) Gadd, C. H.—*The Tea Quarterly*, 1928, 89-93.

(2) Lincoln, F. B. and Bennett, J. P.—*Proc. Am. Soc. Hort. Sci.*, 1926, 253-255.

(3) Thomas, W.—*Plant Physiology*, 1927, **2**, 245-277.

APPENDIX.

TABLE I.

No. of deaths in three Months in 1,500 bushes.	Clean Prune.	Rim Lung.	Cut Across.	Mean	Standard Error.
	67	27	8	34	7·96
Percentage of mean.	197·1	79·4	23·5	100	23·4

TABLE II.

Blocks.	G	H	I	J	K	L
Weight of dieback.	160	180	125	81	85	72
Dry weight of material removed from the bush in 1st tipping in lbs.	13·99	14·20	18·70	20·56	20·10	23·65

Blocks giving high yield in 1st tipping show the least dieback.

TABLE III.

	Clean Prune	Rim Lung	Cut Across	Mean	Standard Error
Pounds of dead material from 1,500 bushes.	346	130	227	234	22·7
Do. as per cent of general mean.	147·6	55·5	96·7	100	9·7

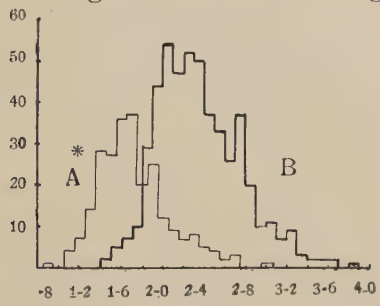
The three pruning systems differ significantly from each other in their effect on the amount of dieback.

NOTE ON TEA SEED SIZE.

F. R. TUBBS.

The effect of tea seed size upon the size of the resultant plant has been examined. Specially selected small and large seed of the same strain were obtained. The large seed ran to about 15,000 seed to the maund and the small seed to about 80,000 seed to the maund. The number of plants resulting after 191 days, expressed as a percentage of the number of seed used, was higher in the case of the larger seed, being 91·4% and 66·0% respectively.

The larger seed was found to produce larger plants in the given time than the small seed, the mean dry weight of the plants being 1·033 grammes and 0·232 grammes respectively. It does not follow, however, that the variation in seed size to be found in a commercial sample of seed is sufficiently large to exert a measurable influence upon the size of the resultant seedlings. The data accumulated in the experiment already described [1] were, therefore, examined from this view-point.



The diagram shows the distribution curve of the fresh weights of the 500 seeds, the height of the curve above each class value for weight being a measure of the number of seeds found in the sample whose weight places them in that particular class. The distribution curve of the fresh weights of 250 pairs of cotyledons is also given. It will be noticed that in both cases the greater part of the sample is found to occur in a small number of adjacent classes. For example 317 of the 500 seeds occur in the classes 1·95 to 2·55 inclusive, i.e., in seven of the total of twenty-five classes.

Neither of the two figures is symmetrical. This is attributable to the fact that in the process of collection, all very small seeds are neglected, whereas very large ones are taken. Thus the range of variation in seed size is artificially restricted in one direction.

The cotyledons, functioning as the food reserves of the seed, do not contribute a constant proportion of its weight, the percentage weight of the cotyledons being slightly greater in large seed than in small. The correlation coefficient is a measure of the extent to which the variation shown by two variables are

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* A. Fresh weight of cotyledons.
B. Fresh weight of whole seeds.

associated. The correlation between the weight of the two cotyledons (expressed as a percentage of the weight of the whole seed) and the weight of the entire seed is small, but significant ($r = 0{\cdot}266$).

The relationship between seed size and plant size was also determined upon the plants resulting from the 250 shelled seed. The dry weight of the cotyledon were calculated in two ways, firstly from its wet weight and secondly by multiplying the total wet weight of the seed by the ratio $\frac{\text{Cotyledon dry weight}}{\text{total fresh seed weight}}$ derived from a sample. No significant difference in the correlations to be discussed was obtained by the use of data derived by the two methods, and the second method may, therefore, be used in future work of this nature. The total correlation coefficient between the dry weight of the cotyledons and the dry weight of the plant was 0·0840, the partial correlation eliminating time of sampling being 0·0936. Neither of these values can be considered to differ significantly from zero and we are, therefore, led to the conclusion that in a normal seed sample the variation in seed size is not sufficiently great to render further selection of the seed for size worth while.

SUMMARY.

1. Extra large seed give a larger percentage of successful germination and larger seedlings than very small seed.
2. The range of variation in seed size in a normal sample of seed is not sufficiently great to render further size selection necessary.

REFERENCE.

(1) Tubbs, F. R.—*The Tea Quarterly*, 1932, 66-69.

THE RECENT TEA DEVELOPMENTS IN RUSSIA.*

In the year 1914 Dr. G. D. Hope wrote a most interesting and informing article in the Quarterly Journal of the Scientific Department of the Indian Tea Association, giving an account of his visit to the tea districts of Georgia in the Trans-Caucasian provinces of Russia. He described the conditions under which tea was then grown in this region and indicated the extent of the industry at that time. However, the interest in the matter at that time was limited for there was no prospect of the rapid extension of tea cultivation in this part of the world, and, beyond the small area of tea grown by the peasants and a few small private owers, the whole of the Georgian tea was in the hands of the Czar himself and one or two rich Russian merchants. The whole area under tea amounted to about 2,000 acres or a little less, and this tea, except such as was in the hands of the peasants who planted it for their own use, was worked by Chinese methods and Chinese men who were responsible for the gardens and for the manufacture of tea.

At the Revolution the tea passed into the hands of the State, but for several years this made little difference in the method of working, and practically no extension of the tea planting in Georgia occurred. But about 1926 a scheme was launched for the increase of the area under tea, and investigations were begun to find out the amount of land with a suitable climate which could be made available for growing tea in Trans-Caucasia. All investigations led to the conclusion that the successful growth of tea would probably be limited to Western Georgia, but that within this area there was enough available land for a very large extension of the industry. Since then progress has been rapid. The new tea planted in 1926 amounted to under 70 acres but in 1927 nearly 1,500 acres were planted and over 5,000 acres in 1928. At present the land under tea in Western Georgia amounts to about 55,000 acres and the present intention is that, within about three years, this area will be multiplied between about two to three times. Such an area, as will be seen, will be a substantial factor in the future supply of the tea world, though, with the increase of prosperity in Russia, it is estimated that that country alone will much more than absorb all the tea that Georgia can produce, without affecting her present imports from the other tea-producing countries of the world.

But in view of the present circumstances it may be worth while to review the conditions under which tea is produced in Georgia in

* By Dr. H. H. Mann.—Reprinted from *The Quarterly Journal of the Indian Tea Association*, 1932, Part II pp. 55-69.

a slightly more detailed manner than was done by Dr. Hope in 1914 when tea planting was little more than a hobby of an emperor and certain rich merchants.

The tea area of Western Georgia lies in a triangular area of land at the extreme east of the Black Sea. This is enclosed on the north by the Caucasus Mountains, on the south by the Armenian Mountains, on the east by the ridge which joins these two mountain ranges. It is open on the west. Under these circumstances it receives a rainfall greater than in almost any other part of the Soviet Union. The rainfall is fairly well distributed throughout the year. This area is also protected from the winter cold which prevails in practically all other parts of Russia, and thus, though the winter temperature is lower than we are accustomed to associate with tea cultivation, yet the area is entitled to class itself as sub-tropical.

Coming to details, the actual rainfall varies from 100 inches near Batoum to about 50 inches in the northern part of Western Georgia The distribution of this rainfall at Chakwa, which was the first tea centre, is shown in the following average figures for each month of the year.

	Inches.
January	10·00
February	6·80
March	5·76
April	5·76
May	4·56
June	7·44
July	7·12
August	9·28
September	10·68
October	12·12
November	10·68
December	9·76
	99·96

The main difference between this rainfall and that of the best Indian tea districts lies in the fact that so much of the rain falls in the cold weather. Much of this rain, in fact, falls as snow and it is quite interesting to see photographs of the tea almost covered with a thick layer of snow.

The rainfall just given, however, represents the best conditions of the area. In the northern and eastern portions, the total rainfall is much lower and in some cases, where tea has been planted, it does not much exceed 50 inches per annum. Moreover, the distribution is not so good as that found at Chakwa, and there is liable to be

drought in April and May, when the tea should be growing as vigorously as possible. The total quantity and the distribution of the rainfall limits to a very marked extent the actual area which is fit for tea planting, and most of the centres for which details of rainfall were given by Dr. Hope in 1914 are now recognised as being quite unsuitable for tea. But even if these centres are left out, there still remains a very large portion of Western Georgia in which the rainfall at least is fairly satisfactory for tea.

On the other hand, in no part of Western Georgia are the temperature conditions really satisfactory, and, even at the most favourable points, the months from November to March are much colder than is desirable for tea cultivation. Even near Batoum, which represents the mildest climate in the country, the minimum temperature during these months may go as low as 22°F. (−5·7°C.). It is true that this low temperature does not occur every year, but in most seasons it goes low enough to damage seriously the higher jâts of tea. I have myself seen young tea shoots nipped off by frost in the early part of December in this very region. In the remainder of the area the conditions are liable to be even more severe, and there are records of temperatures as low as 10°F (−12°C). Of course, such temperatures are very occasional, and the normal minimum winter temperature is much higher than this, but the possibility of the occurrence of such low temperatures will always make tea planting difficult and will prevent the use of the more delicate types of tea. The coldest month is February, and, as will be quite clear, this has an important bearing on the way in which the winter work of the tea garden can be carried out and on the date at which plucking can commence in the following season.

The extent of the long cold weather, which I have tried to describe, will tend, of course, to reduce the length of the plucking season, and, hence, the quantity of tea which can be obtained per acre. On the other hand, the climate during June, July, August and September is very suitable for the vigorous growth of tea, and there seems to be no reason why during the height of the season very strong and vigorous flushes of leaf should not be obtained.

Turning to the question of the soils of Western Georgia, it may at once be stated that hitherto practically all of the tea that has been planted has been put out on the low hills and plateau lying at the foot of the great mountains to the north and south of Western Georgia. Between these and the Black Sea there lies a region of flat clay land and swamp very little above the flood level of the rivers. Most of these lands, even when drained, do not seem likely to be suitable for tea and under the present arrangements in Russia they are likely to be utilised for other commercial crops. On the low hills and plateau

to which I have referred, there has been only a limited amount of cultivation hitherto, though in suitable places, grapes and certain of the hardier types of oranges (tangerines chiefly) have been cultivated extensively and will be cultivated more in the future. The main food crop of the people is maize, which is grown both on the low flat land to which I have referred and on the plateau and hill land which is suitable for tea.

The soil of these low hills and plateau lands varies a good deal, but most of them consist of a red soil with a somewhat heavier and yellower sub-soil. At intervals among this type of soil and sub-soil one comes across a sandier surface soil with gravel underneath. In fact a very large part of the area reminds me very much of a good deal of the teela and plateau land of Cachar and will probably have all the difficulties which have been found on such land in India. The soils of the original tea area near Batoum, Chakwa, and Osurgetti have been very carefully and thoroughly studied by Professor Zakharoff, and I doubt whether a more thorough study of soils in any particular place has ever been made in any part of the world. His studies show that all these soils contain very little lime—as indeed is necessarily the case if tea is to flourish. The acidity of the soil varies of course, but is usually represented by a pH value of 5·0 to 5·5.

Similar soils are found in other parts of the region, though the impression I got was that on the whole in the northern and eastern parts of the area the soils are poorer and less suitable, while there are apt to be patches of land which seems to be spoilt for the purposes of tea by the presence of a substantial amount of calcium carbonate.

The general impression which I get of the soils of Western Georgia as compared with those of north-east India is that on the whole they are poorer than most of those usually planted in the Indian tea districts. However, while it is usual in India for the sub-soil to be fairly light (though of course examples of heavy soils occur even on plateau land), in Georgia the sub-soil usually appears to be heavier than the surface soil. This at once introduces difficulties with regard to the drainage and with regard to the securing of deep root development for the tea plant.

At this point I may say that the analysis of soil from Chakwa given by Dr. Hope in 1914 does not represent the ordinary common type of tea soil in Georgia. It shows far more lime than is usually found and moreover suggests more clayey soil than is generally utilised. On the other hand the amount of organic matter shown by Dr. Hope is much higher than is generally found in almost any part of the Georgian tea area.

The original tea which was planted in Georgia consists of hybrids obtained from various sources, China, Japan, India and Ceylon. Originally high jât seed was obtained from Assam but the plants from this source were found to be unable to resist the winter cold and were gradually abandoned. In fact, of the old tea now growing in Georgia, the best jât that I found was from seed said to have orginated from Ceylon. It was very mixed, but among the plants were some which were decidedly good jât.

With the new development since 1926 there have been renewed efforts to find out whether any of the better jâts of tea can be utilised in Georgia. So far results indicate that the suitability of the genuine Assam Indigenous or Manipuri types is limited, and it is pretty certain that they will only be useful for commercial tea in a very small portion of the area. For the rest, the land has been planted with hybrid and China tea derived in part from India (chiefly from the Darjeeling district), from Japan, and to a less extent from Ceylon, while a large part of the new area has been put out with seed derived from the old bushes already growing in Georgia itself.

It is, of course, a very serious handicap to tea cultivation in Georgia that the really high types of tea cannot stand the climate there, but the handicap is greater than appears at first sight, because, while high jât tea seed can be obtained so as to give fairly uniform plants, it seems at present impossible to get hybrid or low jât tea seed which give plants of uniform productive power, for the seeds are usually collected in India, Ceylon, Japan, or even in Georgia itself, from a mixed lot of plants which are themselves of very unequal productive power. Hence it will be seen that it is of prime importance that the young plants should be carefully selected so as to reject those which give little leaf and a large quantity of flower and seed. It is in fact, a great desideratum that a method should be devised whereby the productive power of any plant can be judged with some approach to accuracy from the condition of the plants at an early stage. Such methods do not appear to be worked out for seedlings in any tea-growing country, but it is one of the matters to which considerable attention is being given in connection with the new tea area in Georgia.

Most of the land so far planted during the last three or four years has been put out "seed-at-stake", and the tendency is for "hedge-planting" to be adopted, for reasons which will shortly appear. The distance between the rows is usually $5\frac{1}{2}$ feet (1·75 metres). In future, nurseries will be used to a very much greater extent than has been done hitherto though it is intended to carry on "seed-at-stake" planting on a very considerable part of the area. During the last and the present seasons, under this latter method,

large numbers of seed are planted in the row, a method which allows the removal of a considerable portion of undesirable plants later on, while still leaving enough to form a satisfactory hedge of plants. Planting is usually done between January and June. The seed put out in the later months, that is to say in April, May and June, even in the climate of Georgia, is likely to be burnt off by the sun just above the ground and so give unsatisfactory plants later on. Undoubtedly, the best time for planting tea seed in Georgia is in the first three months of the year.

The growth of plants under Georgian conditions is, of course, slower than is customary on the plains of India, but it does not differ widely from that on well-prepared land in the Darjeeling district. The critical time with the plants, however, seems to be the first cold weather, and at this time a certain proportion of the plants from every class of seed hitherto used have been killed. The difference between the resisting power of seed from various sources is very remarkable and from the results and tests made the choice of sources of seed in the future will be determined. In view of the heavy sub-soil which is usual in Georgia, it has proved to be of great importance to loosen the sub-soil into which the roots penetrate and the difference between the growth of plants where this is done and where it has been omitted is very remarkable indeed.

One of the features which will strike an observer from India is the extent to which mechanical methods are adopted in connection with all possible operations in tea culture. Thus, for instance, wherever the slope of the land allows, the soil is prepared for planting by the use of heavy tractors, ploughs and sub-soilers. Further, almost all inter-cultivation of the tea after planting is done by machines, and after much experimenting the actual machine used for this pupose is a small petrol motor cultivator made by Siemens-Schuchert of Germany. The inter-cultivation done by this machine is very satisfactory, so far as I can judge, and enables about two-and-half acres to be cultivated in a day of eight hours, using one and three-quarter gallons of petrol. This machine, of course, does not actually keep the soil loose in the rows themselves and this must be done by hand, but over about 75% of the land it certainly seems to do very well and very much better than all the attempts I have seen at cultivation of tea by animal power.

A very considerable portion of the tea already planted lies on slopes which tend to erode badly, just as has been the case of the steep slopes of both India and Ceylon, and as a result it is quite clear that the prevention of such erosion is one of the biggest problems which face those who are now responsible for tea cultivation in Georgia. Careful terracing was adopted in parts of the early planted tea

gardens, but a method for dealing with the heavy slopes which has now been decided upon is that of planting in contour trenches about eighteen inches deep which are made by hand and then filled in as far as possible with surface soil. In addition to this, cross drains are put in on all but the slightest slopes, as the heavy sub-soils render such drains dug down to a depth of three feet almost a necessity for the production of healthy tea.

From what I have seen during the past two years I think it may be taken that the tea in Georgia will begin to yield in the fourth year after planting, and I should, say, on the whole, that the plants are likely to be nearly a year later in reaching their full growth of yielding power than is customary in the plains of India. Plucking has hitherto been done on a system which has been tried and rejected in the more advanced tea-growing countries. The actual number of pluckings has been small, as is still customary in China and Japan, with the result that the bushes have largely "run away" in the middle of the season, and so closed up before the end of September. This of course, has been partly caused by the lack of a sufficient amount of labour for plucking—a lack which will be difficult to supply in the future and which forms perhaps the biggest obstacle to Georgian tea cultivation.

This leads me to what is perhaps the most interesting development of mechanization which has been attempted in connection with Georgian tea culture. Mechanical plucking has been usually looked upon in the East Indies as an impossibility, and everyone, both there and elsewhere, recognised that no mechanical method of plucking can be imagined which does not cause much bad, torn and broken leaf to be plucked, but all the same the Japanese have used for many years a system of plucking by shears which is said to increase sixfold the plucking capacity of each worker. These Japanese shears are now in general use on the estates in Georgia, though, on the smaller plots hand-plucking is still carried on. The workers in Georgia have, however, gone one stage better than the Japanese shear, and now at least two machines have been devised which will pluck the leaf far more regularly and at a still more rapid rate. Of course, the use of these or any other mechanical method of plucking will require that the bushes are definitely shaped to suit the method, and that the plucking shall be more frequent than has been usual in Georgia in the past. In spite of everything, at the best, there will be a very large amount of broken leaf, and it is recognised as necessary that the leaf going into the factories shall be sorted out so as to separate, as far as possible, the cut leaves and tips from the properly plucked shoots. This matter is, in hand, and one pneumatic method of such separation has already been devised and is in use at the Chakwa factory.

Only one-third of the tea area which will ultimately be planted in Georgia will be in the form of estates such as we know them in the East Indies. Even at present, a very large proportion of the tea area is cultivated by peasants who either make the tea themselves by hand methods or, as is now more frequently the case, send it to one of the small factories which are being dotted about the tea areas, and extension of this peasant tea, in the form of collective holdings ("Kolkhoz"), is one of the most interesting developments at the present moment. The importance which is attached to it may be judged by the fact that out of fifteen factories now in existence in Georgia, about ten are devoted to the manufacture of tea so produced.

This leads me to the question of factories, and I may say at once that those which have been erected during recent years are of very good design and are equipped with the latest machinery. The factory at Chakwa, in the original home of tea in Georgia, is a very large one even according to Indian standards. In this, as elsewhere, the latest methods of the East Indies have been copied and most of the machinery is of a similar type to that used in the most up-to-date plantations in the East. Under the conditions in Georgia it is clear that withering of the leaf must be of a more or less controlled type, and withering in lofts with fans is, therefore, usual.

Though all the mechanical devices customary in the East have been adopted in the factories, yet the Russian workers are not by any means satisfied with the amount of mechanization hitherto attained. In fact, as in other industries in Russia, there is at present a passion for mechanization, in order that labour may be saved, and I should not wonder that within a year or two the Georgian authorities may be able to reach a degree of mechanization which has not been attained elsewhere in the world.

The tea produced hitherto has been of a very ordinary type. A recent London Market opinion on these teas read as follows:—

> "All are clean sweet liquoring teas of nondescript neutral character with no trace of commonness or burn. They evidence careful manufacture and grading, and indeed are a most interesting lot. It remains to be seen whether from the climate and soil of Georgia it will be possible to produce any characteristic flavour."

The lack of quality in Georgian teas indicated by this opinion may probably be partly due to the essential conditions of tea growing in Georgia but it is also largely a result of the methods of pruning, and partly of plucking systems. It is likely that the general crop of tea will improve though at present I cannot picture the production of a really good and flavoury tea in the country.

As would be expected from what has been already written, the yield of tea per acre in Georgia is likely to be considerably below what we are accustomed to get in the plains of India. If, however, we compare the yield in Georgia with that which it is customary to obtain in the higher estates of the Darjeeling district, it will be found that the old tea in Georgia is now yielding at least as highly as most of these gardens. In 1930 the old tea in Chakwa was giving about 350 pounds of made tea per acre. With the adoption of better methods and the use of considerable quantities of manure this yield was raised in 1931 to between 400 and 500 pounds of made tea per acre. As far as one can estimate, I should think that with careful treatment, that is to say, good cultivation and pruning, and plucking by more modern methods, it ought to be possible to get nearly 450 pounds of made tea per acre without heavy manuring on well-grown matured tea using the fairly coarse plucking which is at present in vogue in Georgia. This, it will at once be recognised, is a relatively small yield when the quality of the tea is, at the best, only medium, and hence it is looked upon as very important that this yield should be increased by means of manuring. Hence large numbers of experiments in manuring are being carried out both on mature and on young tea in various parts of the already planted area. As in most other places increase in yield follows very closely the amount of available nitrogen in the manure used, but the quantities used are very much greater than what we have been accustomed to consider normal in the Indian tea districts. It is probable, however, that manures, especially nitrogenous manures, will be quite cheap in Russia in the future, so that it will be possible to apply such manures on a very extended scale. It is hoped, in fact, (and I think the hope is a reasonable one), that a yield of between 600 and 700 pounds of made tea per acre on well-grown mature tea will ultimately be produced. The extensive use of heavy dressings of manure is one of the points in the plans for tea culture in Georgia which will place the industry in a rather different position from what would be expected otherwise.

At present, in Russia generally, there is a very great belief in the value of scientific assistance in connection with the development of industries, and in no industry is that value more emphasised than in the case of tea development. There has, in fact been established already what is termed the "All-Union Tea Institute". This is really a large scientific institute for the study of the problems which tea culture in Georgia presents. The centre of the Tea Institute work is a very fine laboratory building situated at Osurgetti in the heart of the new tea areas, and it has branches furnished with small laboratories at two other centres namely, Chakwa, the original home of tea in Georgia, and at Zugdidi, the central point in the northern part of

the districts. These centres are well supplied with highly-trained scientific experts, from whose work we may expect very many results of great importance in the future. The matters which are being studied at present are of course, those which are specially important for tea in Georgia. Thus, for instance, a most elaborate study has been, and is being made on the resistance of various types of plants to frost and quite important results have already been obtained. I expect that within a very few years it will be possible by mere inspection to mark down the plants which are likely to resist frost and also to be good yielders of leaf.

Again, in other parts of the world's tea area it has not been a matter of supreme importance to breed special types of tea plants, because many of the recognised jâts of tea from India were extremely good, and suitable for almost all the conditions prevailing in India, Ceylon or Java. On the other hand, in a region like Georgia which is almost on the limits of tea cultivation, one of the most important matters of investigation is to find the most productive type of plants, which will stand the conditions which prevail during the winter in the country. The development and growth of such plants, so as to produce as large a quantity of tea as possible to supply the needs of Georgia, is likely, of course, to be a matter of many years of work, but it is recognised that, though this is the case, it is essential that it should be proceeded with.

Moreover, it will be seen that the question of vegetative propagation takes on a new importance under these conditions. Of course, tea plants have been propagated vegetatively in Assam as well as in Ceylon and Java for many years, and has been the hobby of a considerable number of planters. I remember seeing accounts of work in this direction as far back as the 'seventies of the last century, but the matter has not been of vital importance where seed of good and reliable type, suitable to the circumstances, could always be obtained. Where this is not the case, the matter takes on a new importance and hence a considerable amount of study is being devoted to working out practical methods by means of which the plants can be propagated vegetatively on a commercial scale.

Another matter to which a good deal of study is being devoted is that of the best way in which erosion can be prevented in Georgian conditions. The matter is not so simple as seems to be the case at first sight, for any method adopted must be one which ultimately leads to the greatest economy of labour. In this, as in so many other matters, the question of labour economy is very important indeed.

It would be impossible here to indicate even in outline the lines of investigation which are being taken up with enthusiasm by the scientists now attached to the Institute in Georgia. On the whole,

now, the work is of a very much more practical character than it was when I first went to Georgia in 1930. Experience is being gained, and as a result the directions of research are being modified so as to deal more with the actual practical problems of tea cultivation and manufacture than was the case until recently.

In one matter I have particular admiration for the way in which the subject is being approached, namely the study of tea manufacture both as a scientific and a practical problem. In no direction does it seem that less progress has been made in tea study than in the knowledge of what actually goes on during tea manufacture. In spite of the large amount of study given to this mater in the last thirty years we are still very largely in ignorance of what happens during black tea manufacture, and what are the causes of the changes which take place. This problem is being approached now in Georgia by a group of men, who, I feel confident, will make a very great deal of progress during the next few years.

Considered as a practical process, tea manufacture has, of course, enormously improved since the time when I first came into touch with it, but on the whole these advances have been in two directions. The first of these is on the engineering side, whereby the machinery then used has been replaced by far more economical and efficient types than was the case in those days. On the other hand, by the adoption of far more cleanliness in tea factories and by creating conditions of moisture and temperature under which both withering and fermenting proceed most favourably, a great deal has been done to bring tea manufacture under closer control than was formerly the case. But the Russian scientists, impelled again by the scarcity and expensiveness of labour, have already got the conception of tea manufacture as an entirely automatic process—at least from the point at which the leaf leaves the withering houses, and they are proceeding with very active work with this aim in view. How far they will be successful, only time can show, but I should not be surprised that the entry of these efficient minds and sufficient enthusiasm into this study may lead to developments which have hardly struck the imagination of workers hitherto.

This is not the place nor the time to give an estimate as to what will be the importance of Georgian tea cultivation in future to the world in general and to the old Indian tea industry in particular. It is still not clear how far the plans which have been made will be completely successful, that is to say how far the tea area, which it is planned to put out, will be of the yielding power which I have indicated as to be expected from good mature tea. But, it is, nevertheless, quite clear that with all the developments that can take place, in Georgia at any rate, Russia can never be entirely dependent,

for its tea supply, on tea produced within its own borders. With increasing prosperity in Russia it is hence probable that the demand for tea from the rest of the world will never be less than it is at the present moment, so that Indian tea planters may look with interest and without concern on the development of tea cultivation in Georgia.

TEA-CIDER—A NEW DRINK IN JAVA*

The so-called "tea-mould" (German: "Tee-Pilz" or "Wolga-Pilz" has already for a long time been known in Europe (Germany, Poland, Russia, etc.) as a culture from which originally a beverage was made as a medicine against rheumatic afflictions and as a stimulant. The therapeutical activity of this beverage as a reducing agent for blood pressure has been established, whereas, being a weak agent, it is also absolutely harmless in the hands of laymen.

A few months ago the "Tea Expert Bureau" in Batavia (an Association of tea planters in Java and Sumatra) got acquainted with this culture and realizing the great possibilities of this beverage as a means to increase the consumption of tea in the Dutch East Indies immediately started a propaganda campaign to popularize the beverage amongst the European and native population. The success was remarkable, not to say phenomenal; thousands of enquiries have reached the Bureau for a piece of the culture and tens of thousands of natives have obtained the culture through the Propaganda Department of the said Association. As a matter of fact the "Tea Cider", as it is named by the Tea Expert Bureau, is on its way to become one of the most popular drinks in Java, both for Europeans and natives.

The process of manufacturing the Tea-Cider, in itself a simple one, is as follows:—

Make tea in the ordinary way, viz. about 40 grammes (about one ounce and-a-half) of dry tea to one gallon of water; remove the tea leaves after the tea has been made; add about 10% sugar to the tea-decoction. The solution should after cooling be poured into a large glass jar or Singapore jar. The fluid is then inoculated with a piece of living tea-culture or with some fluid from a cultivation which has already fermented. The jars should be closed with a clean cloth making the receptacle dustproof, but not airtight. Jar and contents should be allowed to stand; the jar should on no account be moved. After some time a very thin film will form on the surface and will rapidly grow thicker. It is of a creamy colour. The time

* Reprint of Circular issued by the Tea Expert Bureau, Batavia.

it takes the film to form depends upon the climate. In a hot climate like Batavia the film forms after a couple of days, whereas, e.g., in the mountains it takes a few weeks. When a strong thick film has formed the liquid should be poured away and the bottle and film washed with clean cold water. A cooled sugared tea-decoction should then be added again to the cultivation-film and the process repeated. When the tea has fermented sufficiently, depending on individual taste (5-10 days) it should be filtered through a clean, folded cloth into a large container so that the fluid becomes very clear and free from floating parts of mould. The tea-cider may then be poured into bottles, which should be filled so as to leave no air in them. To find ultimate satisfaction in this drink it should, after having been bottled, be allowed to mature for at least a few weeks. The drink has an agreeable taste. It is sparkling, faintly sour and refreshing. In view of the sparkling properties of the drink the bottles should have patent locks as ordinary corks will fly off the bottles.

The better the quality of the tea used, the better the aroma and bouquet of the tea-cider.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON.

Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held in the Victoria Commemoration Buildings, Kandy, at 2 p.m. on Thursday, 28th July, 1932.

Present.—Mr. G. K. Stewart, M.S.C., (Chairman), Dr. W. Youngman, Major J. W. Oldfield, C.M.G., M.C., O.B.E., Messrs. D. H. Kotalawala M.S.C., A. G. Baynham, R. D. Morrison, I. L. Cameron, C. Huntley-Wilkinson, C. C. du Pré Moore, A. W. L. Turner (Secretary), Mr. R. R. Muras (Accountant), and by invitation Dr. Roland V. Norris (Director, T. R. I.), and Mr. J. W. Ferguson (Visiting Agent).

Letters and telegrams regretting inability to be present at the Meeting were received from Sir Wilfrid Woods, Mr. John Horsfall, Mr. C. H. Z. Fernando and Mr. John A. Rogers.

The Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held on the 29th March, 1932, were confirmed.

1. MEMBERS OF THE BOARD OF THE T. R. I.

The Chairman announced that Mr. C. H. Z. Fernando had resigned his appointment from the Board, and the Low-Country Products Association would shortly appoint someone in his place.

The Chairman welcomed Mr. R. D. Morrison and Mr. I. L. Cameron, who were acting for Mr. J. A. D. Finch Noyes and Major H. Scoble Nicholson, O.B.E.

2. FINANCE.

(a) The Statement of Accounts as at 30th June, 1932 was adopted.

(b) *Finance Sub-Committee.*—The Chairman stated that it was the custom to appoint a Finance Sub-Committee for specific purposes as and when required. He had referred to all Members of the Board and the following Sub-Committee had been elected for the purpose of examining the financial position as at 30th June, and the Estimates for the period July to December, 1932:—The Chairman, T.R.I., the Chairman, P. A. of Ceylon, Mr. John Horsfall, Major J. W. Oldfield, and Mr. R. D. Morrison.

The election of the above Sub-Committee was confirmed.

(c) *Grants to the Imperial Entomological Institute and the Imperial Mycological Institute.*—Referring to Circular No. B. 1/32 of the 19th April, the Chairman said that it had been agreed to make contributions of Rs. 750-00 to the Imperial Entomological Institute and the Imperial Mycological Institute and a cheque covering these payments had been sent to the Financial Secretary.

3. TRAVELLING ALLOWANCES.

It was decided that the Secretary should go into the whole question of Travelling Allowances with the Director of Agriculture and check the existing rates and also investigate the proposal of a flat rate, and refer the matter to the Board by circulation of papers.

4. JUNIOR STAFF PROVIDENT FUND.

It was recorded that approval under Section 9 (1) (g) of the Income-Tax Ordinance had been obtained.

The Director said that the Board had already approved certain alterations to the Rules whereby members could utilise two-thirds of their own contributions only for insurance purposes. He had called a General Meeting of the Members of the Junior Staff Provident Fund at which it had been decided to request the Board to reconsider this Rule with a view to allowing two-thirds of the Member's plus the Institute's contributions to be used for insurance purposes.

The Chairman pointed out that the reason why two-thirds of the member's contributions alone had been allowed was because in the case of a member who used both contributions for insurance purposes, the Institute could not withhold any part of the balance standing to a member's credit when that member left the Institute's service.

It was agreed that not more than two-thirds of both contributions could be used for the payment of insurance premia. The terms of all policies to be approved by the Trustees before the policy is taken out.

5. SMALL-HOLDERS.

The Chairman read the following recommendations put forward by the Sub-Committee which had met the previous afternoon:—

1. The Institute to appoint a small-holdings Officer on a salary scale of Rs. 200-40-400 plus house allowance at Government rates so long as no house is provded.
2. A demonstration plot of about 10 acres to be leased in the Uda-Palata area and worked by the above Officer.
3. Subsidiary plots to be selected on small-holders' own land to be worked by the small-holder under the general direction of the T. R. I. Officer. The Committee stress the importance of selecting the right type of small-holder for this purpose as the success of the work will largely depend on the personality and influence of the persons chosen.
4. In view of the fact that the question is largely an economic one, the Co-operative Society should be approached with a view to help being afforded towards the purchase of manures and other necessities.
5. Leaflets in the vernacular to be prepared for issue after demonstration work has been started.
6. Lectures and demonstrations to be given in bought leaf factories.

Mr. Kotalawala in supporting these proposals pointed out that there was a feeling among small-holders who, incidentally contributed according to Estimates some Rs. 9,000-00 to Rs. 10,000-00 annually by way of the cess to the Institute's funds, were not receiving very much in the way of compensating benefit.

The Director of Agriculture also spoke in support and intimated that the Minister for Agriculture and Lands attached considerable importance to the question of some special operations being undertaken to assist the small-holders.

The Chairman remarked that the financial aspect must receive consideration in view of the Institute's finances and it should be the endeavour of the Board to ensure that such measures as are agreed upon will be of real practical help to the small-holders.

Mr. Kotalawala and the Director of Agriculture were of the opinion that work on the lines suggested by the Sub-Committee should be carried out by the Institute and after general discussion it was decided that the financial provision be sanctioned forthwith and that the details be settled after the Board has studied Dr. Gadd's Memorandum and the conclusions of the Sub-Committee.

It was also agreed that a special officer be appointed forthwith to work on behalf of small-holders as recommended by the Sub-Committee.

In view of the delay which had already taken place in regard to this question of small-holders the Chairman gave his personal assurance that the matter would be proceeded with as soon as the Board had decided the details of the scheme.

During the discussion mention was made of:—

(a) *Demonstrations which had recently been held in Peradeniya.*—The Director of Agriculture pointed out that these were well attended and promised to notify the Director of the Institute when such demonstrations were to be held in future.

(b) *Bought Leaf Traders' Association.*—The Director said that on the formation of the Association, he had written and asked if the Institute could help it at all with lectures and demonstrations, etc.

6. MANUFACTURE OF MID AND LOW COUNTRY TEAS.

(a) The Chairman intimated that a Conference had been held in Colombo on the 14th July, at which representatives of agency firms, buyers, brokers, planters, and Dr. Norris and Dr. Evans had been present. This Conference had been convened for the purpose of putting the scientific officers in direct touch with the requirements of the tea market.

He considered that this Conference would have beneficial results and it was hoped to hold frequent conferences of this nature in future.

The Director pointed out that he had arranged for Dr. Evans to attend Low and Mid Country Planters' Association Meetings in order to initiate full discussions of manufacturing problems.

In addition a special bulletin on the manufacture of mid and low country teas would shortly be issued.

The Board agreed that everything possible should be done with a view to improving manufacture particularly of mid and low-country teas.

(b) *Experimental work at St. Coombs Factory.*—The Chairman said that the Director's view had been forwarded under cover of Circular No. A. 10/32. The basis of the proposals was that the Board should authorise a more definitely experimental manufacturing policy in the factory. As this might to some extent interfere with the commercial routine, the Superintendent could not be expected to take the responsibility of such a policy. The Director's proposal was that in order that such experiments should only be carried out on a systematic and carefully thought out plan, the experimental programme should be considered and sanctioned by the Experimental Sub-Committee. In this connection he thought it would be most useful to have on this Sub-Committee a Broker representative and he suggested the name of Mr. R. H. Horne of Messrs. Forbes & Walker.

Mr. Huntley-Wilkinson said that the Experimental Sub-Committee should be given authority to initiate such experiments but the Board should take the responsibility for any fluctuation in prices which might result.

The Board approved of the above proposals and decided to invite Mr. R. H. Horne to join the Experimental Sub-Committee.

(c) *New Machinery.*—The Director said that it would be helpful if facilities could be granted to the Institute's Staff to inspect new type of machinery installed on tea estates. They could then perhaps co-operate with superintendents in working out the best method of employing such plant. Such a procedure would be helpful to estates and also give the Institute much useful information.

It was decided to refer this suggestion to the C. E. P. A., and to the P. A. of Ceylon.

7. PUBLICATIONS.

The Chairman said that certain suggestions had been circulated to the Board under Circular No. B. 3/32 of the 18th May, with a view to standardising the procedure regarding publications and the majority of the members had wished the matter discussed at the Board Meeting.

It was finally decided on the grounds of economy that in future:—

(a) Estate Agency Firms to be limited to one free copy.

(b) The Ceylon Association in London to receive 70 free copies as at present.

(c) One free copy to be sent to the Planters' Association of Ceylon.

Two free copies to be sent to the C. E. P. A.

One free copy to be sent to the L. C. P. A.

(d) Estates to receive a free copy for the superintendent and an additional copy for each assistant superintendent when requested.
(e) Teamakers are not eligible for free copies.
(f) The Director to continue to send free copies to other scientific bodies who place this Institute on their free list.
(g) Complimentary copies on the present basis to be sent to certain bodies and individuals.

Mr. Huntley-Wilkinson referred to the question of secrecy with regard to results of experiments.

The Board decided to adhere to the decision made at the meeting held on the 29th March, 1932.

8. TEA SEED.

The Director stated that correspondence was in progress with Tocklai Station in regard to the original mother type of dark and light leaf variety of tea seed.

In reply to a question by Major Oldfield, the Director said that estates with tea seed for sale could register their names with the Institute, giving full details of the seed and he would then be able to pass the information on when anyone requiring the seed applied to him. He added that he did not think it advisable for him to recommend any particular tea seed grower.

9. BIRD LIFE AT St. COOMBS.

This subject was the result of a letter written by Mr. John Still to Mr. A. G. Baynham, suggesting that efforts should be made to increase the breeding of insectivorous birds in tea districts with a view to combating disease.

The Director stated that Mr. King already had the matter in hand.

It was suggested that the Director should write to Mr. W. E. Wait, Mr. W. W. Phillips and Mr. G. M. R. Henry on this subject.

10. CONFERENCE OF THE T. R. I.

It was decided that the next Conference should be held on January 27th, and 28th, and that Papers should be limited to 3 subjects and should be dealt with on the first day; and the second day set apart for the inspection of the Laboratories, Factory and Estate. It was also decided that the Chairman of the Planters' Association of Ceylon should be invited to preside at the morning session, and the Chairman of the Low-Country Products Association at the afternoon session.

The Meeting terminated with a vote of thanks to the Chair.

A. W. L. TURNER,
Secretary.

NOTICES.

The Institute's Laboratories are situated at St. Coombs, Talawakelle, and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station c/o Messrs. Hemachandra & Co., Forwarding Agents.

Visitors' Day.—The first Wednesday in each month has been set aside as Visitors' Day at St. Coombs Estate, when it is hoped anyone interested will visit the Station.

Visitors at other times are welcome but the Staff may not be free to show them round. Such visitors, on arrival at the Factory, are requested to ask for the Teamaker.

St. Coombs Estate is reached by taking the turn-off opposite culvert marked 28/10 on the Nanu Oya-Talawakelle main road. A signpost has been erected at the turn-off.

Publications.—Applications for the Institute's Publications should be directed to the Secretary, at Victoria Commemoration Buildings, Kandy, and *not to the Director's Office.*

ROLAND V. NORRIS,
Director.

EDITORIAL.

T. R. I. CONFERENCE.

The Third Conference of the Tea Research Institute will be held at St. Coombs on Friday and Saturday, January 27th and 28th, 1933, when the programme will be as follows:—

FRIDAY, JANUARY 27TH.

MORNING SESSION 10 A.M.—12-30 P.M.

Chairman: Mr. A. G. Baynham, M.C., B.A., Chairman, Planters' Association of Ceylon.

10 a.m. "Review of the Institute's Programme".—Dr. R. V. Norris, D.Sc., F.I.C., Director.

10-30 a.m. "Recovery from Pruning". Mr. F. R. Tubbs, M.Sc., D.I.C., A.R.C.S., Plant Physiologist.

11-30 a.m. "Recent Experiments in Tea Manuring". Mr. T. Eden, M.Sc., A.I.C., Agricultural Chemist.

AFTERNOON SESSION 2-4 P.M.

Chairman: Sir Marcus Fernando, Kt., M.D., B.Sc., Chairman, Low-Country Products Association of Ceylon.

2 p.m. "Certain aspects of Tea Manufacture". Dr. D. I. Evans, Ph.D., B.Sc., Biochemist.

3-30 p.m. "Tea Cider". Dr. C. H. Gadd, D.Sc., Mycologist.

SATURDAY, JANUARY 28TH

No formal papers will be given but facilities will be afforded to visitors to inspect the Laboratories, Factory and Estate and opportunities will be provided for informal discussions with members of the Staff.

It will greatly facilitate the arrangements if those who propose to attend the Conference will fill up one of the forms already circulated (*vide* T.R.I. Bulletin No. 9) and return this to the Director *as soon as possible*.

TEA RESTRICTION.

The likelihood of tea restriction being imposed at an early date necessitates a careful examination on the part of planters, of the methods available for bringing this about. It is no doubt a simple matter to reduce crop, but it is obviously desirable that the methods

employed should be such as to cause the minimum of permanent damage to the tea. If one can go further and use methods which may be of ultimate advantage so much the better, and it is hoped that the article which will be found elsewhere in this issue will show that this, on many estates, is a perfectly practicable proposition.

It is to be feared that in many cases the temptation to reduce expenditure by cessation of manuring will cause this method of procuring restriction to be adopted. Taking a long view, however, this is not sound policy and, unless precautions are taken, damage may be caused which will be incapable of rapid rectification when restriction is once more removed. It is appreciated that some reduction in manuring may be essential and that economies must be achieved. The possibility of making such economies by the substitution of inorganic artificials for the more expensive organics is discussed in another article which should receive serious attention at the present time. With circumstances as they are, it would appear much sounder to accept any slight risk which *may* be involved by such a change-over and maintain a reasonable basis of manuring rather than make an excessive cut in the manurial programme necessitated by the continued use of the more costly organic artificials.

TORTRIX.

The season is approaching when Tortrix will be at its maximum activity. This may start in December or January, and the most concentrated period of egg-laying usually lasts about three weeks. It is necessary to bear in mind that the incubation period of the egg is about one week. Therefore, to obtain the greatest measure of profit, egg masses should be collected every five days during the period December to March. If egg masses are only collected during plucking rounds, a certain proportion are bound to escape detection which will give rise to extensive attacks by the caterpillar.

WITCHES BROOM

For a considerable period a disease of tea known as the "Yellows" disease has occurred in Nyasaland. In many respects this closely resembles "Witches Broom" in Ceylon and it is therefore of considerable interest to find that in Nyasaland the disease is now attributed to a deficiency of sulphur in the nutrition of the bush and that very successful results have been obtained by the application of sulphates.

Experiments have recently been started in Ceylon to see whether similar treatment may prove efficacious in the case of "Witches Broom".

TEA CIDER

Satisfactory cultures of the "tea fungus" required for the preparation of Tea Cider have now been prepared and can be supplied to those wishing to make a trial. Development of this "Industry" is, however, at present held up pending a decision by the Excise Department as to the terms of the permit which apparently is required before Tea Cider can be made.

BAG WORMS.

Many people who follow agriculture are familiar with the insects collectively known as "bagworms". They are generally of two types, one in which the caterpillar affixes small pieces of twig to the outside of the case, and the other in which the twig is replaced by fragments of leaf. The basis of the caterpillar's conical tent is a matting of silk, which is extremely tough. These are now being used in Japan for the manufacture of articles, previously made of canvas or leather, such as ladies' bags, golf bags, letter cases, belts, and even sports shoes.

The method employed is to collect the full-grown cases (the larger kinds may be one-and-half inches long, or more), slit them up, scrape off the twigs or leaf, and sew them together into larger pieces for use. No further preparation is necessary, and the material is ready for use.

STAFF.

The Director will be proceeding on home leave on the 8th February. During his absence Dr. C. H. Gadd will act as Director, in addition to his own duties.

ROLAND V. NORRIS.

TEA RESTRICTION.

ROLAND V. NORRIS.

In view of the likelihood of restriction of crop being imposed during the coming year it seems desirable to discuss various methods by which restriction may be attained. Several alternatives are available and the relative merits of these will depend on how far they secure economy as well as restriction, and on their effect on the future strength and vitality of the bush. The latter consideration is perhaps likely to be overlooked but is of particular importance, as it is obviously undersirable that methods should be adopted which may possibly check normal production for a considerable period after restriction is removed.

We may perhaps group restriction methods under the following heads:—

(a) Plucking methods.
(b) Resting of fields.
(c) Restriction or modification of the manurial programme.
(d) Manufacture.

(a). PLUCKING.

A finer standard of plucking may be adopted. This not only restricts crop but may confidently be expected to improve quality. Finer plucking may of course involve more frequent plucking and this not only adds to plucking costs but is an additional strain on the bush. If the normal plucking round is maintained then breaking back may be necessary which again means more time and labour.

If, on the other hand, the normal standard of plucking be maintained then restriction may be obtained by increasing the length of the plucking round. Here again breaking back will be necessary unless the extra leaf is left on the bush. The latter is beneficial in so far as it increases the leaf surface and thus increases the food supply assimilated by the bush. It is inconvenient, however, in that the level of the plucking table will gradually be raised and as stronger growth usually arises from the centre, the bush will tend to acquire a conical shape and the usual flat plucking table may be difficult to maintain.

Finer plucking will increase the cost of production but this may not be material as it may well be offset by the improvement in quality. Any successful attempt to improve quality must have a far-reaching effect in improving tea prices generally and is therefore desirable in itself apart from the restriction aspect.

The margin of restriction available under the head of plucking will naturally vary greatly in different estates. There is undoubtedly considerable scope in many cases and particularly on these estates, unfortunately not few in number, where coarser plucking has lately been carried out to reduce cost of production and to compensate for reduced yields due to cessation of manuring.

(b). RESTING OF FIELDS.

This would appear to be one of the most advantageous methods of restriction. In the first place it gives an immediate and readily calculable degree of restriction, the method is capable of considerable elasticity of application and finally, particularly in the case of weak fields, it is likely to be of considerable ultimate benefit to the tea. Various possibilities may be considered.

(1). Taking the widest application first it might well pay estates which normally obtain but poor prices to rest a large proportion of the estate, utilising the export quota thus set free either for the benefit of more profitable estates in the same group or company or selling the quota to outside estates more favourably situated.

(2). Poor and weak fields may be put out of plucking. Should resources permit this will permit of attention to bush sanitation, replacement of uneconomic bushes and other general improvements before the field is again brought into plucking.

(3). Resting individual fields, for a period to be determined, before or after pruning.

RESTING BEFORE PRUNING.

The advantage of this is that the bush is given every opportunity for the formation of ample food reserves before pruning. Much better recovery from pruning may therefore be expected and far less loss from dieback and subsequent deaths. This aspect is of particular importance in the Low and Mid-Country up to, say, 3,000 feet.

The importance of adequate food reserves at pruning has been definitely established and is, in fact, now generally recognised by planters.

That disadvantage of the system is perhaps that by this method it is the older leaf that is sacrificed and the total crop will therefore contain a rather higher percentage of young leaf. This, however, will be compensated for if young fields can also be rested.

RESTING AFTER PRUNING.

This method, which is applicable only to a clean or rim-lung prune and not to a cut-across or Travancore, has the advantage that better wood formation is encouraged and as one eventually cuts back

into red wood at the tipping level, better leaf from a manufacturing point of view is more quickly obtained when the bush is taken back into plucking.

In general, resting before pruning would appear to be the more advantageous procedure in the Low-Country. Here the prime consideration is good recovery from pruning. If this is not attained then resting after pruning cannot be expected to be of much utility except purely from the restriction aspect. Since resting before pruning leads to a stronger recovery good wood formation may be expected to follow to some extent from this method also.

The period for which a field should be rested before pruning will depend on the degree of restriction necessary and also on the condition of the field. From the point of view of bush recovery, however, the resting period should not be less than three months if the field is in poor condition.

In the case of resting after pruning there is less choice of the time of resting possible as this will depend on the growth made. In general, for equal periods of resting, a greater restriction of crop will result from resting before pruning.

The resting of weak or unhealthy bushes is a common practice already which has been shewn to have beneficial results. Resting for restriction purposes is really only a wider application.

(c). MANURING.

Cessation of manuring must necessarily reduce crop but the effect may not immediately be shewn and the degree of restriction cannot be accurately forecasted. The rate and amount of fall in crop will vary with the previous history of the field in regard to manures and cultivation, and with soil conditions.

Reduction of yield brought about in this way is really a symptom of reduced efficiency in the bush. Such a condition must be regarded as definitely disadvantageous in the long run and is, moreover, one which may require a very considerable period for its amelioration.

If manures are *reduced* in quantity, which may be economically necessary, every effort should be made to maintain the supply of green material incorporated in the soil. Moreover, the reduction in manure should not fall on one particular manurial constituent. In other words a balanced mixture should be continued. In many cases the cost of such a mixture may be materially reduced by the substitution of inorganic artificials for the more expensive organics. This aspect of the case is discussed in another article in this issue but it would certainly appear preferable to maintain a reasonable manurial

level by the use of inorganic rather than to submit to a cessation of manuring on the grounds of the high cost of the organic mixtures at present in favour.

It should not be overlooked that undue cutting of manures, leading to a weakening of the bushes, may eventually necessitate a reduction in the pruning cycle. This is definitely disadvantageous, leading to a greater proportion of young leaf in the crop and so reducing quality. To avoid this it may be necessary when manuring is seriously curtailed to compensate for this by resting the fields for a period as indicated earlier in this article.

(d). MANUFACTURE.

Under this head there is perhaps less scope for restriction unless one considers cessation of manufacture for a definite period as a practical measure. In the case of many estates at the present time such a step would not appear to be economically possible.

Leaf might, however, be again picked over on arrival at the factory. If this were done the amount discarded would probably be a good deal more than is generally supposed and the teas would be improved.

An extra round of tipping leaf might also be discarded. Tippings and very young leaf only make inferior tea and by eliminating such material restriction would again be combined with an improvement in quality.

Various possible methods of restriction have been indicated in the above notes. No programme can be laid down capable of general application but on most estates it should be possible by the above methods, individually or in combination, to arrive at a system suitable to the particular conditions obtaining.

"Resting" on the whole appears the most advantageous plan. It is economical, easy of control and constructive in that it should lead to an improvement in the condition of the bushes, whereas the other methods discussed tend on the whole in the opposite direction.

SOILS, FERTILIZERS AND THE GROWING PLANT.

T. EDEN.

The problem of obtaining the maximum value from artificial manures is one which has become particularly urgent since the decline of the tea market set in. The most satisfactory basis for manurial practice is that afforded by accurate experimentation on tea, but at present there are relatively few data relevant to present needs though efforts are being made by the Institute to acquire them. Nevertheless, there are certain principles of general application that are not so widely understood as they might be, and to them this article will be mainly confined in the hope that they will prove of use practically, and will help in the interpretation of field experimental results as these become available from time to time.

The first general consideration of importance is that of the relationship of soil analysis to manurial practice. This has already been dealt with in the *Tea Quarterly* (Vol. 1. page 97) but a word in amplification will not be out of place here. There is no difficulty in determining accurately the amounts of the various nutrients that are to be found in the soil. Anyone who is interested in such data can obtain it from half a dozen sources without going out of Ceylon. Moreover, the analyses of different analysts would agree. Where unanimity of opinion might probably be lacking is in the interpretation of the results so obtained. What does a given chemical analysis of the soil mean in terms of plant behaviour? Methods for determining chemically that portion of the plant nutrient that is available are admittedly tentative. They frequently fail for two reasons. They may err considerably in their estimate of what portion is useful to the plant, and they frequently give no information at all as to how rapidly the unavailable portion is transformed into available supplies. It is obviously important to know, so to speak, not only how much palatable food there is in the store room, but also how rapidly it can be transferred to the table. As an example of the kind of difficulty met with in actual practice, Greenhill (*Journal of Agricultural Science*, *1930*, **20,** 560), gives data showing that a series of soils known to differ widely in phosphate content, showed negligible differences in the phosphate content of their soil solution. In actual yield response the plants grown on these soils differred widely, but not in proportion to the total phosphatic supply of the soils.

The foregoing does not invalidate the use of the soil analyses in special cases. Much sound advisory work has been done by combining a wide knowledge of soil analysis with agricultural observation and acumen, or better still with actual field experiments of proved accuracy. In general, however, such work has proved valuable only in special circumstances on well-defined soil types, with a few specific crops. It has been more successful for nitrogen requirements than for potash, and the case of phosphate has been least satisfactory of all.

A way out of this *impasse*, which one hopes may be temporary, has been sought in the analysis of the plant itself, but here again soil analyses and analyses of plants grown on the respective soils do not tally. There is no equivalence nor even a fixed ratio between the amounts of nutrients found in the crop and the amount needed or supplied as fertilizer. By way of illustration, at Rothamsted, winter rain causes a loss of 1·4 bushels of wheat per acre which represents a loss of two pounds of nitrogen in the crop to the plant. It requires eight pounds of nitrogen applied to the soil, however, to make good that damage. Again, the average phosphatic content of the tea crop is lower than the average content of nitrogen or potash: the quantity of phosphate normally applied to the soil is on the other hand greater than the quantities of nitrogen or potash used per acre. In view of the crop analyses it may at first appear a wrong practice to apply such large quantities of phosphate, but experience shows that the utilisation of added "soluble" phosphate is low and never exceeds a 15% recovery of what has been added.—(Russell, 1931, *Artificial Fertilizers*.)

In the face of these inquiries it must be conceded that field experiments offer the best method of judging manurial requirements and that soil and plant analyses should be regarded as ancillary weapons only.

There should be little need at the present time to emphasise the necessity for supplying all the major nutrients in manure mixtures. As far as our knowledge of manurial balance goes, in Ceylon definitely ill-balanced rations seem to be the exception, but in view of financial depression the point may well be stressed that economy in manuring should never be made at the expense of a single ingredient. One nutrient will not work efficiently in the absence of the others. To illustrate this point an experiment may be mentioned in which nitrogen was supplied in the presence and absence of mineral nutrients. Since the plants were grown in pot culture, leaching losses

did not occur, but results showed that the nitrogen recovery by the plant in the pots supplied with mineral manures exceeded that attained in their absence by 50% (Russell, *loc. cit.*).

From the question of balance one naturally passes on to that of the actual ingredients to be used. The phosphatic and potassic fertilizers are simplest to deal with and will be taken first.

Superphosphate—provides a readily available supply of phosphates with a slight benefit in unit price in favour of the concentrated variety.

Basic Slag—compares favourably in unit price with superphosphate, but its real efficacy depends upon its solubility; high soluble slag (over 80% solubility) gives concordantly better results than those of low solubility.

Bone Meal.—In general, experiments have shown that this is not superior to superphosphate either in yield production or lasting effect. Its price range is similar, a slightly higher value being offset by its nitrogen content.

Rock phosphate.—This product, of which Ephos and Safaga phosphates are representative, is the basis for the manufacture of the more soluble superphosphates. It is the cheapest form available and can be obtained at about two-thirds the unit price current for superphosphate. It has been compared under English conditions with low soluble slag, but there is evidence that its performance under the conditions obtaining in Ceylon, viz. high rainfall and acid soils, will be superior to its behaviour in temperate agriculture. It may be regarded as a cheap and valuable source of phosphates.

Muriate of Potash—is undoubtedly the most economical potash salt to use. The saving per unit is about 25 per cent when compared with sulphate and in a rainy climate the possible harmful effects of the chloride it contains are negligible.

Sulphate of Potash.—In comparison with other potash salts, the only distinctive advantage is its better keeping capacity. Muriate if left exposed to damp very readily absorbs water.

ORGANIC AND INORGANIC NITROGEN.

The most debated question regarding manures at the moment is undoubtedly that of the alternative use of organic and inorganic nitrogen. On an average, organic nitrogen costs over two and a half times as much as the inorganic form. At present this additional cost of organic nitrogen becomes a serious item and the question arises whether that extra cost is justified. If there were incontestable experimental results there would be no further need of argument,

but though a good deal of demonstration work has been planned and carried out in Java, India and Ceylon, the results are in many cases contradictory and unconvincing. In briefly summarising these experiments it would not be unfair to say that a case has been made out for bulk manures, but not indubitably for organic artificials.

Three factors which may react in favour of organic artificials are described in agricultural chemical literature: (1) The ameliorative effect of organic matter on soil tilth and microbiological activity, (2) Slow but steady availability, (3) the presence of some stimulating substance akin to vitamin in animal nutrition which exerts an influence out of all proportion to its quantity. The first two deserve serious consideration on their merits. Recent work on the third shows that the quantities required are always present in an agricultural soil even if it is incredibly poor. With regard to the first two points it is well to note that although the text-books of agricultural chemistry refer with one accord to the extensive experiments carried out at Rothamsted, they do not generally distinguish between bulk organic manures and organic artificials. The time is ripe for re-examination of the problem in the light of the Rothamsted results which should clarify the main issue.

The comparison of rape cake with sulphate of ammonia is the only one in the Rothamsted experiments which is relevant to our point. This trial has been made on mangolds grown continuously since 1876. The 52-year averages 1876 to 1928 give the following results;—

Rape cake (98 lbs. N)	21 tons per acre
Sulphate of ammonia (86 lbs. N)	14·4 tons per acre

Here there is a distinct advantage in favour of rape cake, and it may be conceded that the advantage would still remain if the quantity of nitrogen given in the rape cake were scaled down to the level of the sulphate of ammonia. It is a feature of this field that on the rape cake plot the germination is very much better than on the sulphate of ammonia series, and this is reflected in a better stand of plants (even after the thinning out process of "singling") to the extent of between 4 and 5 per cent in 1931, the only year for which such figures are available. The quantity of rape cake applied is two thousand pounds per annum and it is reasonable to suppose that such a quantity supplied annually since 1856 (twenty years before the crop was stabilised as mangolds) has had an appreciable effect on the tilth. Mangolds are particularly sensitive to tilth conditions at seeding and for a considerable time after, and the better stand obtained with rape cake may be taken as an indication that in terms of general robustness of growth the rape cake plots have an undeniable advantage.

Nevertheless, it would be rash to generalize on this basis because of the peculiar nature of an annual crop of this delicacy, and of the very large quantities of rape cake that have been supplied.

This experiment demonstrates the ameliorative effect on soil tilth. If it is held that the increased crop obtained from rape cake shows the superior quality of organic nitrogen, the other side of the picture is shown by a corresponding experiment on barley grown continuously since 1852. For the 76-year period 1852 to 1928 the following averages are obtained:—

Rape cake	(49 lbs. N)	38 bushels per acre.
Sulphate of ammonia	(43 lbs. N)	39 bushels per acre.

There is no superiority shown here despite the six pounds extra nitrogen given as rape cake: nor can it be argued that both plots are overmanured since yields on other plots reach an average of 45 bushels.

This experiment gives no support to a general theory of soil tilth improvement and in addition throws light on the second question that of availability. The small deficiency on the rape cake plot has been a feature of the experiment throughout the whole period, and has not diminished in later years. This indicates that the nitrogen compounds of the rape cake are almost wholly utilisable by the crop to which they are applied. At any rate no large amount of residue slowly becoming available is left in the soil as is the case with farmyard manure.

Turning to point (2) availability, it is of interest that barley is a crop that is only in the soil for some five months and that its nitrogen supply is garnered chiefly in the first half of its life cycle. In the light of these classical experiments, rape cake which contains 5% of nitrogen only, does not seem to behave as a slow acting nutrient with an appreciable residual value. It has no superiority for one of the two crops studied but has for the other. Its superiority can be linked up with its effect on tilth when applied continuously in exceptionally heavy dressings.

Confirmatory evidence for the rapidity of availability of organic artificials is given by Joachim's work on their nitrification (*The Tropical Agriculturist*, 1928, LXXI, 131.). Confining his attention to primary nitrification i.e. nitrification taking place before any large amount of reassimilation of nitrogen by microbial organisms is evident, he finds that the maximum for all types of nitrogenous manures is attained in the sixth week. The percentage of original manure nitrified in that time is given (*loc. cit.*) as follows:

Ground Nut Cake	...	86
Blood Meal	...	46
Fish Guano	...	68
Fish Manure	...	79
Cyanamide	...	64
Sulphate of Ammonia	...	47

Allowing for a considerable sampling error which is inevitable, it is not straining the evidence to say that "organic" artificials are as rapidly available and as rapidly wasted as the inorganic salt.

The writer has previously (*The Tropical Agriculturist*, 1928, **70,** 310) pointed out that the leaching loss experiment of Joachim points in the same direction.

As field experiments and laboratory trials have failed to substantiate the superiority of organic artificials, how has this conviction of their superiority grown up ? We may hazard the opinion that the answer lies in the history of artificial manuring. Organic fertilizers have not always been so much more expensive than inorganic. At a time of high prices when manuring in almost any form was paying, agriculturists were not so interested in the niceties of the inorganic versus organic controversy as they have been of late years. Moreover, in the times of which we speak the balancing of artificial manure mixtures was not so well understood. Many farmers and agriculturists manured solely with one ingredient. The man who used cakes, guanos and offals was, however, *ipso facto* using something in the nature of a balanced mixture since the ash content of these manures is contributing phosphate and to some extent potash. In course of time, in certain seasons he reaped the benefit, and naturally regarded the organic manures as the better proposition. A preference which in one stage of knowledge and under good market conditions may be entirely justifiable may have to be altered when quite different conditions supervene. The essence of the problem is what to do at the present time.

If the foregoing does not prove the case for inorganic artificials, and the writer is conscious that the absence of direct experimental evidence for tea is a serious drawback in the search for finality, it must be conceded that the attendant nutritive risks for yield and general health are at least minimised so long as the colloquially described "gun powder" mixtures are ruled out.

There remain doubts as to effect on quality. Here all that can be said at present is that we have no evidence that quality has suffered from the use of sulphate of ammonia as distinct from organic nitrogen. Cases of deterioration have come to light but in these quantity and ill-balance would fully account for the results. During

the last two years, tea receiving 40 pounds per acre of nitrogen, two thirds of which has been inorganic, has been manufactured separately and compared with similar tea without nitrogen, and no consistent differences have emerged. This is as far as we can take the evidence for and against organic artificials up to the present. A full discussion of the data of the Institute's field experiment will take place at the 1933 Conference when a further year's data will be available.

What are the risks to which the sole use of inorganic nitrogen exposes us ? They do not apparently arise from a too rapid availability; are they associated with a certain diminution of organic matter in the soil ? Taking a liberal estimate of 500 lbs. of organic nitrogen manure as the annual amount commonly used on tea, this amount in the first nine inches of soil represents only ·002 per cent. Such a quantity is a very different matter from 2,000 pounds used annually in the Rothamsted experiment and no one can reasonably compare mangolds and tea with regard to tilth requirements. What cannot be strictly justified on scientific evidence alone, however, may have to be seriously considered in times of depression. The point is that inorganic nitrogen in conjunction with green manuring and the use of tea prunings supplies all the nutrients and organic matter necessary to maintain the tea bush in health, and the soil in tilth, and the use of them is preferable to a cessation of manuring altogether.

Thomson, in the previous issue of this journal, ingeniously presents data regarding the immobilisation of nitrogen by green manures. His contention may have to be modified in view of what has previously been said about availability, and in the light of recent work that, it is only fair to say, was not available at the time his article was written. Richards and Norman (*Biochemical Journal*, 1931, **25,** 1769) have pointed out that fermenting vegetative matter even of high nitrogenous content will immobilise inorganic nitrogen in excess of that predictable by the carbon-nitrogen ratio. They demonstrate that the micro-organisms prefer to use ammonia rather than to undertake the necessary decomposition of protein nitrogen in the plant material. In a striking experiment with bean husks which already contains more than 0·5 per cent. more nitrogen than is required for completing the decomposition according to the "adco" process, they have succeeded in immobilising all of it plus a further 0·62 per cent. Willow peelings which already contained 1·9 per cent. of nitrogen immobilised a further 1·33 per cent.

In conclusion, it may be mentioned that we do not consider these questions solved, but since work in the field and factory on inorganic and organic nitrogen has already been in progress at the Institute for two years, any fresh developments as to their cumulative effect that may conceivably occur will be evident before similar developments occur on estates. In the meantime, whilst watching these results with the greatest care, there are sound reasons for adopting the inorganic forms in preference to a complete cessation of manuring whilst depression conditions last.

DEFOLIATION.

F. R. TUBBS.

II.—THE EFFECT OF DEFOLIATION ON THE YIELD OF FLUSH AND ON THE THICKNESS OF THE PRUNING WOOD.

In a previous article (1) a general description of the effect of defoliation on certain temperate trees was given. In order to examine this problem in its relation to tea, an experiment was set up at the end of August, 1931. Ten bushes were taken as controls, while ten bushes were completely stripped of foliage, all expanded leaves being removed, but the buds left intact. A further ten bushes were treated by removing approximately half the leaves on the bush, but, owing to the difficulty of making this third treatment uniform, the records from these bushes will not be considered. In order to ascertain whether climatic conditions influenced the effect of defoliation, a second and similar experiment was commenced towards the end of February, 1932. Each experiment lasted for 180 days, plucking being done on a ten-day round.

It has already been shown [1] that defoliation affects temperate plants through a reduction of the carbohydrate reserves. The most important external factor affecting the manufacture of reserves is light. The number of hours sunlight per month for the six months preceding and also during the experiments is shown below:

1931	April	May	June	July	August *	September *	October *
	188	183	61	117	34	114	192
	November *	December *	1932	January *	February †	March †	
	173	154		259	258	216	
	April †	May †	June †	July †	August †		
	223	104	105	117	123		

* First Experiment. † Second Experiment.

It can be seen that the two experiments were performed under very different conditions, the first having been initiated after a period of reduced light, and continuing during the sunny weather of January, while the second started during a period of strong light conditions and continued into the dull weather of the South-West Monsoon. If the weather before or during the experiment has any fundamental effect upon the course of recovery from defoliation, it should be apparent on comparing the results obtained, which may now be discussed.

The yield of dry matter in the form of flush is shown for both experiments in Figure I, from which it will be seen that the yields during the second experiment (February to August, 1932) are consistently higher. The two series of differences, namely yield of defoliated bushes minus yield of control bushes, for each of the eighteen plucking occasions is shown in Figure II, and again in a simplified form, obtained by taking running means of three, in Figure III.

A comparison of the two curves in Figure III shows that they both agree in showing a peak between the first and fifth occasions followed by a trough until a second peak occurs between the tenth and fifteenth occasions. The highest values of the peaks occur in the first experiment forty and a hundred days after defoliation, and in the second experiment forty days and a hundred and thirty days afterwards. In each case the final peak is above the horizontal datum line and indicates that the yield of the defoliated bushes had exceeded that of the controls. It will be noticed that in the unsmoothed curves in Figure II, two peaks occurred in the early portion of the second experiment, in contrast to the single peak of the second experiment. This is the only important difference between the results of the two experiments. The first experiment commenced during a period of low yield, when there were comparatively few developing buds, whereas the second experiment was started during more active growth, the yields of the control bushes at the first plucking being 8·44 grammes and 36·95 grammes, dry weight of flush, in the first and second experiments respectively. The additional peak in the second experiment may be regarded as the result of the larger number of buds which are in a sufficiently active state to expand quickly during a period of active growth than during a period of relative quiescence.

The occurrence of two periods during which the defoliated bushes yield more than the controls, which are separated by a period in which the reverse occurs, suggests that the causes underlying the

production of large numbers of pluckable shoots at the two periods in question may not be the same. The first peak, as has already been explained, is due to the expansion of those buds that already exist upon the bush. It will be recalled that at St. Coombs the average time required for the production of a pluckable flush is sixty or more days, whereas the peak here occurs forty days after. It is suggested that this increased rate of growth is the direct result of the stimulus applied by defoliation, which is probably of the nature of a "wound stimulus".

The growth of these shoots is made mainly at the expense of the carbohydrate and mineral reserves within the plant, the young shoots being at first dependent upon the materials they draw from the stem, becoming less dependent as they develop a larger and larger leaf area. The question of the time at which a young shoot becomes self-supporting cannot be answered definitely, since it will depend upon the rate at which it is growing, which varies greatly at different seasons and elevations. The amount of new material produced by a flush during any period is the difference between the rate at which food is being manufactured and the rate at which it is being oxidised in respiration. Respiration is high in young tissues, falling off later, whereas assimilation rises for a time and then falls with increasing age of the leaf. As a result *nett* manufacture reaches a peak some days after the opening of a leaf and thereafter may fall slightly. This sequence of events would occur under ideal conditions where no factor affecting food manufacture varied save age. Under natural conditions great variations from this trend will occur according to the changes in environmental conditions from day to day, and it is therefore impossible to present a nutritional balance sheet for the young flush.

In general terms, therefore, the growth subsequent to defoliation results in a serious drain upon the reserves already present within the bush, and may be regarded as an attempt on the part of the plant to restore the normal leaf surface. This attempt is partly frustrated by the plucking operation, an average of 30·3 grammes and 81·3 grammes of leaf material being removed from each defoliated bush in the first and second experiments respectively during the course of the experiment. This suggests that the trough in Figure II between the fifth and eleventh plucking occasions may be due to carbohydrate deficiency, resulting in decreased yield. During this period the bush is increasing its leaf area partly by growth below the plucking surface but mainly by the increasing number of "third leaves" left when each shoot is plucked. It is, therefore, becoming more able to

produce sufficient food to form new flush, with the result that yields gradually increase once more. The yields of the defoliated bushes thereafter might be expected to approximate to those of the non-defoliated bushes. Instead they are found to rise again above those of the control bushes. This peak may be regarded as a further manifestation of the wound response, which has been delayed by the drain upon the reserves reducing growth until the new leaves could supply the requisite carbohydrate material. The fall in yield of the defoliated bushes at the end of the second experiment is probably due to extraneous causes, since by then a large leaf surface was in existence and carbohydrate supply was unlikely to be limiting growth.

In the previous article on this subject [1] it was shown that under temperate conditions defoliation reduced growth in thickness of the stem. This is only of interest to the planter in so far as it may affect the thickness of wood at the pruning level. In order to investigate whether removal of the leaves injuriously affected the growth of wood in the case of tea, branches were marked with white paint about three inches above the previous pruning cuts, and their thickness recorded at the beginning and end of each experiment. In the first experiment the average increase in thickness of the wood of the control bushes was 0·139 cm. and of the defoliated bushes 0·067 cm. In the second experiment the values were 0·138 cm. and 0·073 cm. respectively, the wood measured being on the average about half an inch in thickness. The differences between the increase in wood thickness of control and defoliated bushes are real, the first experiment giving a level of significance of nearly 100:1 and the second experiment of over 100:1.

The question now arises as to whether the periods of decreased yield of the defoliated bushes are compensated for by the periods of enhanced yield. At the end of one hundred and eighty days the yields per bush were:—

	Control	Defoliation
First experiment	47·7 grammes	30·3 grammes
Second experiment	102·1 grammes	81·3 grammes

The difference in the first experiment has a level of significance 20:1 and in the second just under 20:1.

A difficulty in the interpretation of the yields lies in the heterogeneity of the bushes which resulted in a very high error being associated with the experiment. To carry the analysis a stage further, the yield of each bush at each plucking was expressed as a

percentage of the mean yield for that bush, and straight line regressions of $\frac{\text{yield} \times 100}{\text{mean yield}}$ upon time were calculated for each bush. By this means the best fitting straight line of the equation $y = a + bx$ was obtained for each bush. The coefficient "b" expresses the rate at which the yield of a bush is altering with time relative to the mean yield of that bush. By using the yield expressed as a percentage of the mean, differences due to soil or to bush size are eliminated. In the first experiment the value of "b" for the control bushes had a mean value of 0·78 and for the defoliated bushes of 3·70. The difference is significant, the level of significance being nearly 70:1. This shows that the defoliated bushes were increasing in yield at a greater average rate during the six months of the experiment than were the control bushes. In other words, they show a significant recovery during that period. In the second experiment the change of yield with time does not differ significantly the mean values of "b" being 3·23 and 4·67 for the control and defoliated bushes respectively.

The effect of defoliation upon recovery after pruning was tested in the case of the second experiment. The results show that although the defoliated bushes showed a lower rate of recovery than the controls, the difference could not be regarded as real.

To sum up, defoliation depresses the yield initially, but a flush is produced soon after, the speed at which this occurs being dependent on the number of active buds fit to expand quickly. This recovery is not maintained, however, the succeeding fall in yield being probably due to depletion of carbohydrate reserves. As the leaf area increases, the supply of carbohydrates is enhanced by that from the leaves, and a second peak of growth occurs. The defoliation also results in decreased wood thickening, while observations suggest that delayed recovery from pruning may also result although the latter point requires further examination.

The bearing of these results upon estate practice is of importance, connected as they are with the whole question of the reserves of the plant. Defoliation may occur as the result of plucking, of tortrix or nettle grub attack, or of the presence of *Cercosporella*. Plucking is a mild defoliation operation and will tend to induce subsequent flushes as wound responses while it will also result in reducing wood formation. The latter effect is unlikely to be of importance unless exceptionally severe plucking is the rule, but it suggests that resting, quite apart from its effect on the reserves of the bush, will have a beneficial effect upon wood growth. Knight [2] has shown that

removal of lateral growths impedes stem thickening, even where the central stem is allowed to grow unchecked. The acts of tipping and subsequent plucking will therefore combine the effects of defoliation and removal of laterals. Resting after pruning is therefore likely to have a beneficial effect on the thickness of the pruning wood and an experiment is in progress to measure this effect. Care should be taken not to confuse this with the effect of resting before pruning which is of advantage in increasing the carbohydrate reserves of the plant prior to the period of recovery, which at first must be entirely dependent upon stored reserves.

The answer to the question of how to treat a field that has suffered a severe defoliation by insect or fungal attack may be deduced from the hypothesis that has been put forward to explain the foregoing results, i.e. that removal of the leaves of the bush causes a wound response which at first only gains partial expression apparently owing to carbohydrate deficiency setting in, its completion being delayed until the deficiency is remedied. It would therefore appear that the best treatment is to *rest* the bushes in order that they may not be subjected to the continual strain of flush removal. After a period of rest from a month to three months according to the severity of the attack, the bushes may be levelled off, and plucking recommenced. The longer period of resting will not be necessary except in the case of complete defoliation, which never occurs with tortrix attacks, but may result from *Cercosporella* or nettle grub.

In the case of the latter pest, it is sometimes found advisable to prune the field in order to destroy the insect. The time of pruning is of great importance. If pruning is delayed until the bush has reached the condition shown by the experimental bushes after forty days, i.e. when it has drawn upon its reserves to produce new leaves, recovery from pruning can only occur at the expense of reserves which have been already depleted. It is, therefore, advisable to prune immediately defoliation has occurred, if that treatment is decided upon, or to delay pruning until the bushes have been rested.

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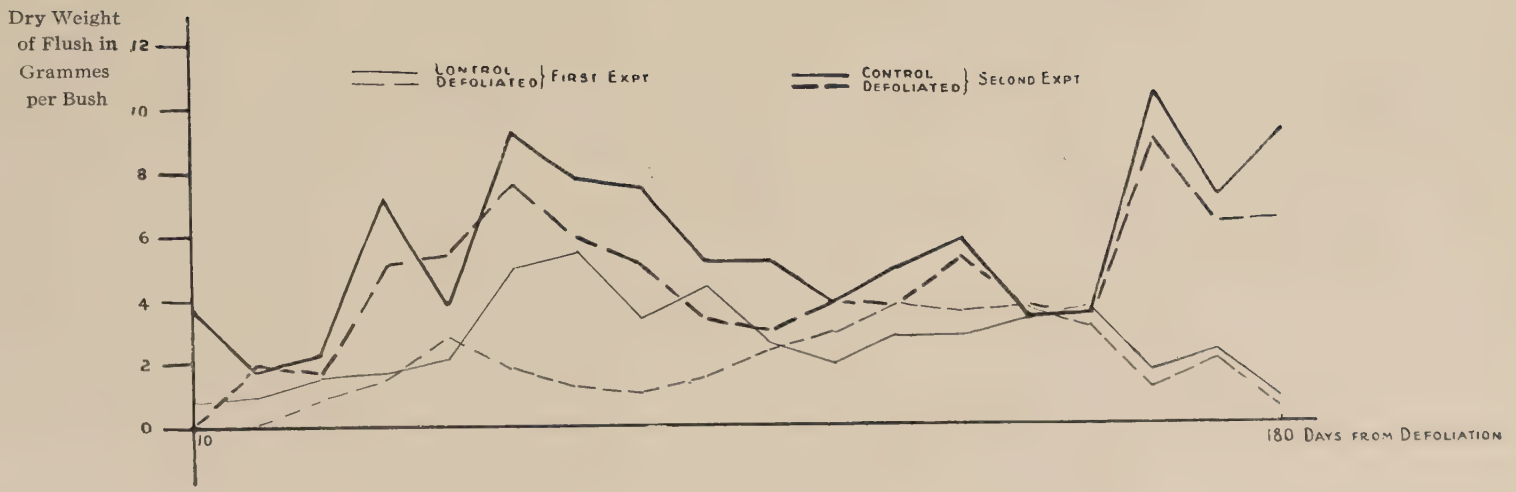

Fig. I

Yields of defoliated and control bushes expressed in grammes of dry matter.

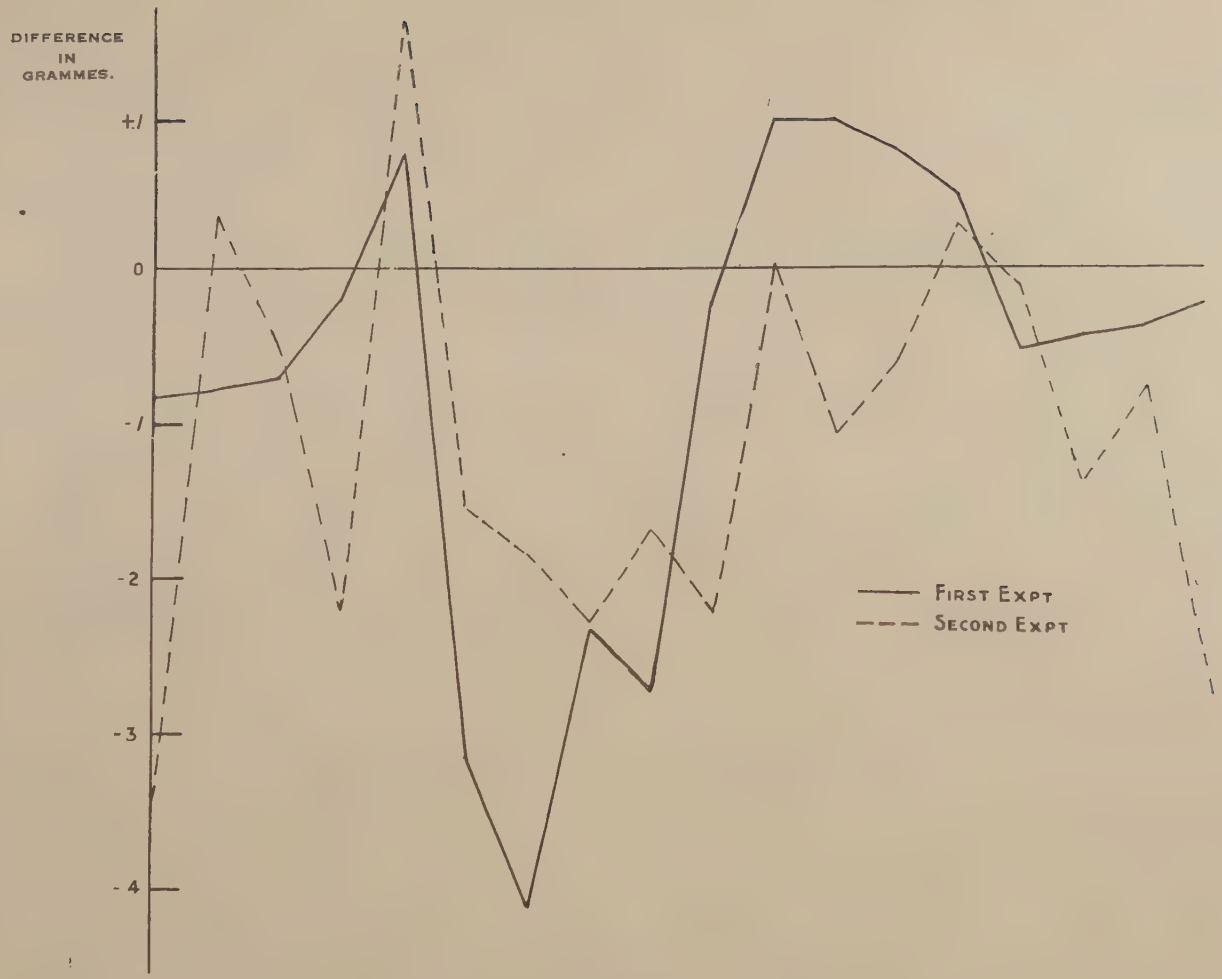

Fig. II

Defoliated yield minus control yield in grammes of dry matter.

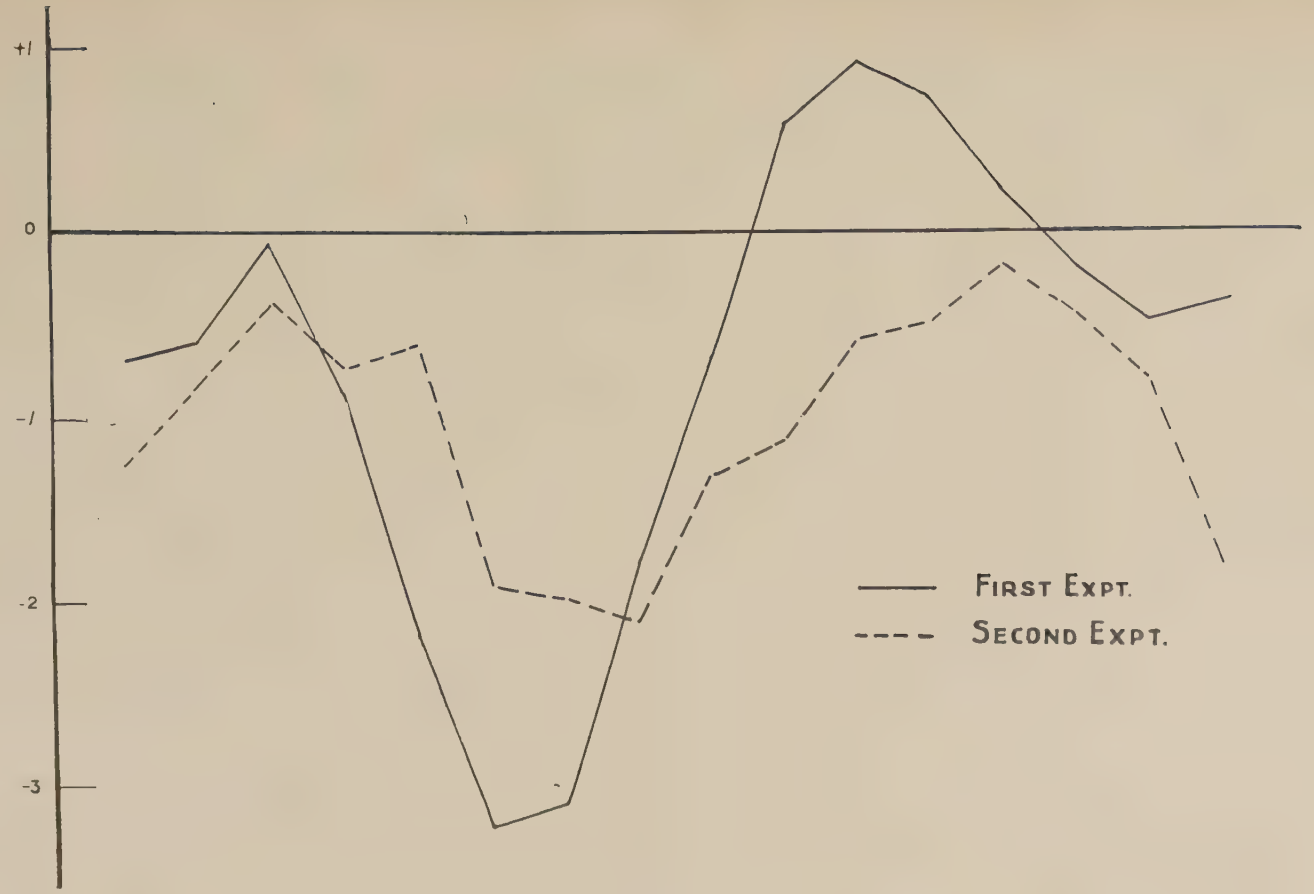

Fig. III

Defoliated yield minus control yield in grammes of dry matter. Curve smoothed by taking running means of three.

A NOTE ON THE VEGETATIVE PROPAGATION OF TEA.

F. R. TUBBS.

The tea plant (*Camellia Theae*) is propagated commercially by one of two methods—by seed or by layers. The former method is by far the most commonly employed, being used in all the tea districts of the world. In China and Formosa propagation by layering is also undertaken. The bulk of the information available upon the method of layering comes from Formosa, where the planters consider that, in spite of the large difference in cost compared to propagation by seed, the method is justified by the fact that only by layering can the characteristics of the parent be transmitted unchanged in the whole of the resulting population. This attitude has not changed since 1904, when Kingsford and Bamber [1] stated that about 70 per cent of the tea in Formosa was propagated by layers, the cultivators considering that the continuance of the special characteristics of their oolong teas could only be ensured in this way.

The method used is quite simple; the ground around the parent bush being ploughed up, the lower branches of the bush are bent down, twisted sharply near their origin and buried, the upper part of the branch bearing the leaves being left above the soil. Movement is prevented by pegging down with slips of bamboo. The young plants are severed from the mother bush, and put out in the plantation six months or more after the layering operation.

These methods are found to be most successful with the "China jât" type of bush. The broad leaved "Assam jât" is found to root less readily by this method.

While the commercial use of this method is likely to be small, owing to the high cost of propagation, the clonal propagation of tea has a considerable bearing upon research work upon the crop. The size of an experiment, and consequently the number of experiments which can be carried on simultaneously, is controlled by the variability of the crop upon the area selected for experiment. This is made up of two portions, that due to differences in the soil within the experimental area and that due to differences between bushes. The removal of the second portion by the use of uniform vegetatively propagated plants will result in a large reduction in variability. The careful selection of seed-bearers which has been practised by estates producing tea seed has resulted in far more uniform types being produced than was the case earlier in the history of tea planting.

Nevertheless, this is not sufficient and resort must still be made to vegetative propagation if uniform experimental areas are sought. The usefulness of grafting and budding for this purpose is contingent upon a successful method for obtaining uniform stocks, since seedling raised stocks are likely to produce large variations in the character of the scion worked upon them. The methods requiring investigation are therefore propagation by cuttings, layering and stooling.

Propagation by hardwood cuttings has not been found to be successful, the percentage of success being only in the neighbourhood of 5 per cent when planted out in open nursery beds. The use of hardwood cuttings has been reported to have had successful results on an estate near Nagoda and from specimens kindly supplied to us by the Superintendent (Figure I) it is evident that successful establishment has occurred. The use of soft-wood cuttings has been tested by Tunstall [2] who reared them in a glass propagator and who obtained 53 per cent of rooted cuttings after six months. This method would appear to be very promising for rapid multiplications of selected bushes.

Layering is a much slower and more expensive method, since it can only be performed on large shoots and the number of suitably situated branches in a bush is limited. It possesses the advantage of providing initially larger plants than do soft-wood cuttings. The normal twisting or nicking of the layered stem at the point where rooting is desired is necessary to encourage the formation of shoots, omission to do so resulting in very disappointing results. The advantage of this method is that it enables the more rapid production of a number of grown bushes of a clone, from which an abundant supply of soft-wood cuttings could be obtained. Stooling has similar advantages.

A further method of obtaining a limited number of identical plants is by splitting the young plant or seedling. If seed is allowed to germinate until stem and root are just discernible, it is possible to split the young plant in such a way that one cotyledon remains attached to each section (Fig. II). The halves grow and develop normally and by this means pairs of identical plants can be obtained.

Attempts to divide the young seedling up into even larger numbers are being made, but such attempts must be made before the radicle is more than five millimetres long. On older seedlings the best results have been obtained by cutting back 9-12 months old

Fig. I

Rooted Cuttings from Nagoda Group.

Fig. II

A seedling split into
halves.

seedlings to one inch of stem and dividing into four or more fragments. Great care must be taken in such work to maintain the fragments in a saturated atmosphere. The rooting medium that is being used is washed sand.

Acknowledgments are due to the British Consul at Formosa and the Superintendent of Nagoda Group for information supplied.

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NOTES ON THE WORK OF THE SCIENTIFIC STAFF.

In consequence of the discovery that the "Yellows" disease of tea in Nyasaland, which in many respects resembles "Witches Broom" disease in Ceylon, is caused by a deficiency of sulphur, experiments have been laid down by the Mycologist to determine the effect of sulphur in the latter disease. An area of infected tea has been divided into eight plots, four of which have been manured with a complete mixture containing no sulphur, while to the other four was applied a similar mixture as regards its feeding value in nitrogen, potash and phosphoric acid, but containing sulphur in the form of sulphates. The degree of infection of each bush was estimated and recorded on a marking system at the time of manuring and the plots will be periodically re-examined. Up to the time of writing no visible improvement is noticeable but it is too early yet to draw any conclusions.

Witches Broom does not appear to be due to any deficiency of the ordinary manurial constituents, as experiments carried out by the Plant Physiologist in which complete manurial solutions were injected through the branches of affected bushes have failed to bring about any recovery.

An examination has been made into the nature and number of organisms brought into the factory on fresh leaves. This is of interest in view of the theories put forward from time to time that the changes occurring during manufacture are brought about by micro-organisms. It was noticed that the number of viable organisms was

materially reduced when the leaf was broken up, e.g. by mincing, the fungi falling from 52,000 to 12,000 per gramme and the bacteria from 116 millions to 9 millions per gramme. Following up this observation counts were made of the organisms present at various stages of manufacture. It was found that similar reductions take place during rolling, particularly in the first roll. Fewer organisms were found in the fermented tea just before firing than on the freshly withered leaf. These observations strongly support the view that tea fermentation is not due to the activities of micro-organisms.

Work on Nettle Grub has continued at the Passara Sub-Station. There has, however, been a considerable falling off both in the number and the severity of attacks reported and, except on a few estates, the pest has hardly been of a serious nature during most of the present year. So far spraying with soap solution remains the best means of dealing with the pest.

The Tortrix egg parasite received from England has been successfully bred in the laboratory and large numbers of these are now in cold storage ready for a field trial as soon as Tortrix makes its appearance in sufficient numbers, which will probably be at the end of the year.

It has been found that Trichogramma will parasitise the eggs of the castor silkworm moth, *Attacus ricini*. The percentage parasitisation is not very high but from twelve to twenty parasites are reared from each egg. The parasites are also markedly larger than those reared from *Ephestia* eggs, being nearly twice as long.

Two or three samples of tea seed attacked by maggots have been received. The latter all died before reaching maturity so that it has not been possible to make a definite identification. It is unlikely that this is a serious pest, however, and it is possible the seed was already dead when attacked.

A case has occurred of *Crotalaria* being attacked by a small capsid bug, *Ragmus importunitas*, Dist. This bug is not known to attack other economic plants and is not easily noticed until full grown when flight movements may attract attention. If the plants are well grown, cutting and burying is the best procedure. If the crop is young and it is not desired to cut it, a soap and water spray may be applied.

The pruning experiments at St. Coombs, Peradeniya and Galatura are in full plucking and the data obtained will be discussed at the Institute's Conference in January. Striking results upon the

amount of dieback have been obtained at Galatura. An experiment to determine the effect of chemical composition on the dieback or growth of pruned branches has been initiated.

The variety trial has now been planted up.

The manurial experiment at St. Coombs has now reached the end of its second year and the results to date will be presented at the Conference. It will be remembered that this experiment is designed to show the effect of different levels of manuring with nitrogen and potash and the relative effect of three types of nitrogen, blood meal, cyanamide and ammonium sulphate. The leaf from these plots is being manufactured on the small scale plant so that the influence of treatment in quality can be examined. From December direct comparisons between the three forms of nitrogen will be possible and these results should be of the greatest interest in view of the present tendency to reduce the cost of manuring mixtures by the substitution of inorganic artificials for the more expensive organics.

Further work on the establishment of cover crops has been carried out. Up to date, of those species tried at St. Coombs, *Parochaetus communis* has proved by far the most promising. Financial provision has now been made by the Board for more extensive work on cover crops and green manures and steps are being taken for trials and demonstrations of a considerable number of varieties.

The time of the Biochemist has largely been taken up with advisory work on estates and with factory experiments. Large numbers of tea samples continue to be received mostly with reference to moisture content and firing conditions. Market conditions and the low prices now obtaining have, however, focussed attention on manufacture generally and many factories have been visited and the system of manufacture checked with beneficial results. Several addresses on manufacture have also been given to District Planters' Associations.

In view of the prevailing conditions it was decided that factory experiments at St. Coombs should not be restricted to the small scale plant but that the commercial plant should also be utilised, one of the objects desired being to obtain more coloury liquors with as little sacrifice as possible of other qualities.

A slow wither for the evening leaf has been tried out. As a result of this the evening leaf has been withered for an average of $37\frac{1}{2}$ hours, instead of about 18 hours. There was no difficulty experienced in keeping this leaf for the time period, and the infusions of the made tea were not mixed or dull as a result of mixing slow withered leaf with quick withered leaf.

The most obvious effect of allowing the evening leaf to wither slowly is the saving in fan power effected. When the evening leaf is manufactured the following morning it never gets any natural withering during the wet weather, but the fans have to be employed on it for long periods if it is to be ready by 10 to 11 a.m. the next day. When it is allowed to wither slowly the fans are seldom required for more than to take off the surface moisture. Thus, in November the fans were only worked for 60 hours on the evening leaf, as against 197 and 173 hours for the morning and noon leaf.

The average loft temperature recorded with the fans on was 71-65·6°F, withering thus proceeding with a hygrometric difference of 5-6 degrees.

The increased period of withering undoubtedly gave more coloury liquors but at the same time resulted in an undesirable loss of pungency and briskness.

Lighter rolling was next tried in order that a smaller percentage of leaf should be separated in the early dhools, but this again did not lead to any material improvement. Subsequently, heavy rolling was again resorted to from the beginning but all the dhools were double roll breaked. By the procedure a considerable amount of the dhool is returned to the roller and the average duration of rolling is increased, the dhools are more even in character and orange pekoe leaf is separated from the leaf grades. The orange pekoe is derived almost entirely from succulent stalks which give very thin liquors and the removal of these from the leaf grades has undoubtedly improved the liquors of the latter.

Concurrently with the above experiments, trials were made of different periods of fermentation. These led to the conclusion that the best period under St. Coombs conditions, where the average temperature of fermentation is about 68°F, is from 210-240 minutes for all grades. Under the conditions prevailing, however, there would appear to be a fairly wide time range within which little difference is observed in the resulting teas.

Observations have also been made on the effect of taking the B. O. P. from 1, 2 & 3 dhools, 1, 2, 3 & 4 dhools and dhools 1-5.

When the first three dhools only were utilised, the appearance of the B. O. P. was improved. The increase in valuation, however, was not sufficient to compensate for the smaller percentage of B.O.P. obtained. The addition of the fourth dhool gave added colour to the B. O. P. liquors, and, on the whole, considering the size of the fifth dhool, it has appeared most profitable to utilise all five dhools. Further experiments are proceeding.

A Small Holdings Officer was appointed in October and has since then started work in the area Gampola-Kadugannawa-Gampola. Contact is being established with the small-holders, village officials, co-operative and other societies, and certain areas will shortly be selected for demonstration plots on small-holders own land and for a plot to be worked by the Small Holdings Officer himself.

ROLAND V. NORRIS.

NOTICE.

The Institute's Laboratories are situated at St. Coombs, Talawakelle, and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station c/o Messrs. Hemachandra & Co., Forwarding Agents.

Visitors' Day.—The first Wednesday in each month has been set aside as Visitors' Day at St. Coombs Estate, when it is hoped anyone interested will visit the Station.

Visitors at other times are welcome but the Staff may not be free to show them round. Such visitors, on arrival at the Factory, are requested to ask for the Teamaker.

St. Coombs Estate is reached by taking the turn-off opposite culvert marked 28/10 on the Nanu Oya-Talawakelle main road. A signpost has been erected at the turn-off.

Publications.—Applications for the Institute's Publications should be directed to the Secretary, at Victoria Commemoration Buildings, Kandy, and *not to the Director's Office.*

ROLAND V. NORRIS,
Director.

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